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AIR-STREAM POLLUTION CONTROL

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AIR-STREAM POLLUTION CONTROL

Proceedings of a Seminar

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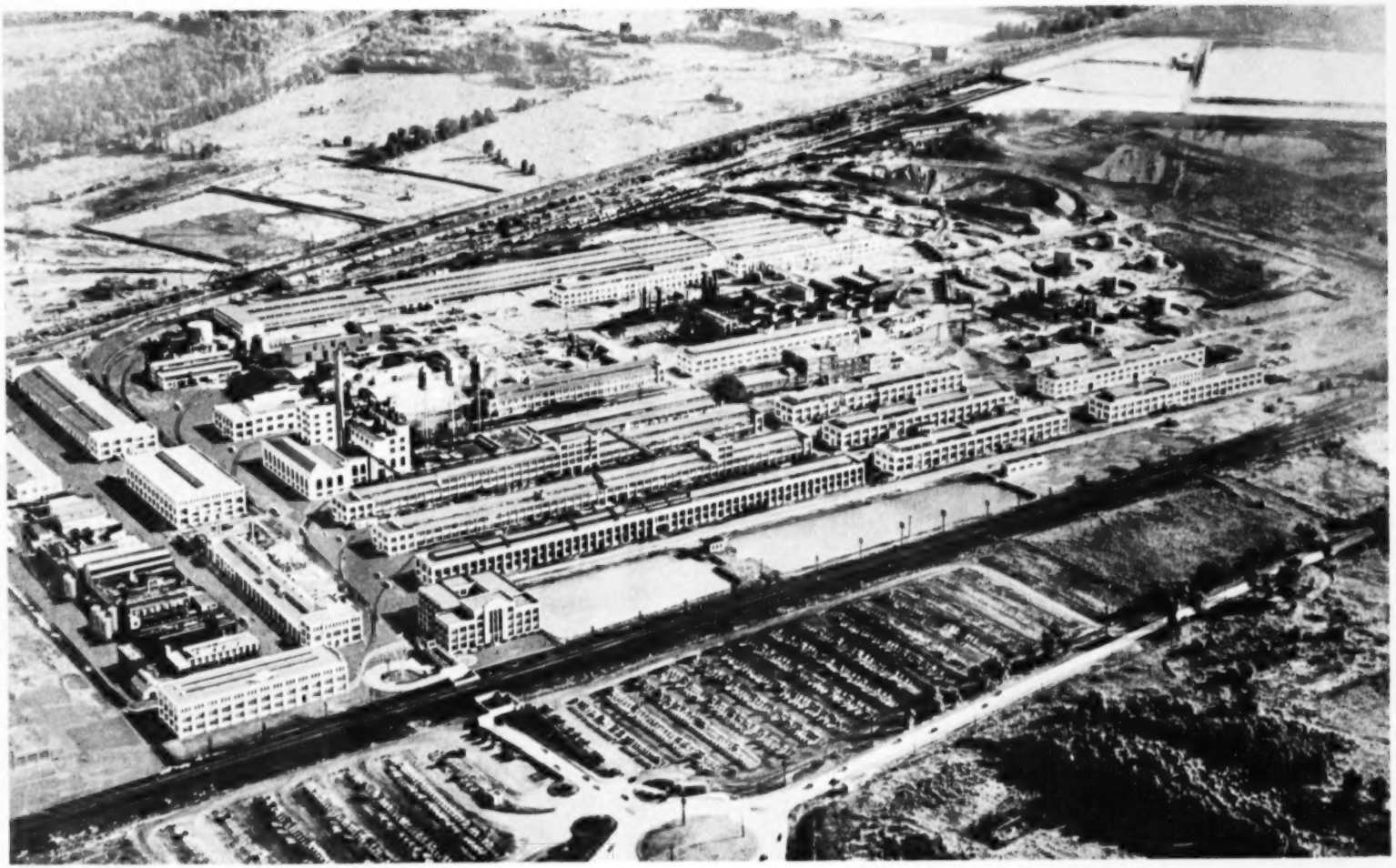

The manufacturing area of Cyanamid's Bound Brook plant where new waste-treatment facilities were recently completed. The area covers about 100 acres.

FOREWORD

The control of air and stream pollution represents a continuous challenge to the nation. It is especially significant to industry, because of the never ending growth of communities where plants are located, and because of the evolution in industrial processes.

American Cyanamid Company recently completed a new waste treatment facility at its Bound Brook, New Jersey plant that embodied significant developments in industry-community, state and federal cooperation in the field of pollution control.

To mark the occasion, Cyanamid was honored to serve as a joint sponsor with the United States Public Health Service, the New Jersey Department of Health, and Rutgers University in an Air-Stream Pollution Control Seminar held June 4, 1958 at the Bound Brook plant, and attended by more than 200 representatives from industry and government.

The importance of the various papers presented by distinguished authorities at the Seminar urged the value of making available complete texts to a wider audience concerned with the progressive course of effective pollution control. The report includes research reports on control programs, and investigations of Air and Water Pollution Control measures.

CONTENTS

Page

SEMINAR KEYNOTE
Daniel Bergsma, M.D., M.P.H. 1

NATIONAL AIR POLLUTION CONTROL PROGRAM
Vernon MacKenzie 5

STATE AIR POLLUTION CONTROL PROGRAM
Miriam Sachs, M.D., M.P.H. 13

ENGINEERING CONTROL OF AIR POLLUTION PROBLEMS
W. Brewster Snow, Ph.D. 23

NATIONAL STREAM POLLUTION CONTROL PROGRAM
Gordon E. McCallum 29

STATE STREAM POLLUTION CONTROL PROGRAM
Robert S. Shaw 35

TOXICITY STUDIES IN STREAM POLLUTION INVESTIGATIONS
Charles E. Renn, Ph.D. 41

THE CYANAMID STORY AT BOUND BROOK
James C. Lamb, III, Sc.D. 47

SUMMARY OF SEMINAR
Dr. Daniel Bergsma 61

SEMINAR KEYNOTE

Daniel Bergsma, M.D., M.P.H.*

There has been general recognition for many years that excessive pollution of public waters is detrimental to health. The development of a comparable awareness that excessive pollution of the atmosphere can be detrimental to health is more recent. Only a few years ago, a faculty member of one of the country's famous universities, speaking at an air pollution control conference in New Jersey, caused quite a stir when she flatly asserted that there is no relationship between air pollution and health. It is interesting, however, that she declined to offer her paper for publication.

This seminar today, arranged as it is by one of our large American industries, provides evidence that industry has an awareness of the effects upon health of pollution of the air we breathe or the water that we use.

Air and water are alike in some ways and unlike in others. Both are essential, both flow in streams, both can be polluted, and pollution of both is susceptible to control. Excessive pollution of either water or air can have negative consequences for the polluters themselves or for others some distance away.

There are available relatively precise standards for determining the degree of water pollution. Equally precise standards for determining the degree of air pollution are not yet developed. Whether we deal with air or water, however, the hazard of pollution is related to the nature of the pollutants; their volume; the effects of combinations; weather factors such as wind velocity, temperature, and humidity; and the size of the population affected.

Fortunately, progress in the reduction of air pollution need not wait upon the adoption of precise standards. We know that if the volume of pollutants is reduced, the effect is beneficial. It isn't necessary to know at what point smoke from open burning garbage becomes toxic in order to accept the idea that it is better for almost everybody if the garbage can be disposed of without burning it in the open. The cumulative result of such thinking and its application is a substantial reduction in the volume of smoke which used to hang like a pall over the countryside.

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*Commissioner of Health, State of New Jersey.

The State Department of Health has had responsibility for the control and regulation of air pollution in New Jersey since September, 1954 when Chapter 212, Public Laws of New Jersey, better known as the Air Pollution Control Act, was signed by Governor Meyner. This law created an Air Pollution Control Commission in the State Department of Health to formulate and promulgate, amend and repeal codes and rules and regulations controlling and prohibiting air pollution throughout the State.

The Commission created by this Act was appointed by the Governor and sworn into office in February, 1955. Since the organization of the Commission, several chapters of an Air Pollution Control Code have been promulgated. A chapter on the control and prohibition of air pollution from refuse disposal and salvage operations became effective on May 1, 1956; the chapter on control and prohibition of air pollution by smoke became effective January 1, 1958; the newest chapter on control and prohibition of air pollution from combustion of solid fuel, became effective July 1, 1958.

The Commission brings together many disciplines, many points of view, and many different experiences. It is representative of private interests, governmental agencies, and the general public. Its membership has embraced persons who were learned in science, medicine, law, and government. The Legislature, by design, made industry a party to the rule making procedure in that representatives of industry may attend and render briefs at public hearings. It is a democratic procedure to give those who are governed a voice in the councils of government.

Those of you who attended the air pollution conference on May 19th in Trenton were doubtlessly impressed that it is not easy to write sensible, realistic codes. We asked for suggestions. After thinking, many of you said you could not make specific suggestions at the time and that specific proposals could only result from consideration of individual processes and individual industrial problems. Your thinking helped the Commission by influencing its approach.

Copies of a Progress Report of the New Jersey Air Pollution Control Commission are available here today. At the outset, it indicates why control of air pollution is important to all of New Jersey in these words:

"New Jersey is both very heavily industrialized and densely populated. The State of New Jersey ranks forty-fifth in the nation according to geographical size, it ranks eighth in population, and sixth in the value of its industrial production. Consideration of possible sources of atmospheric pollution, i.e., from general, industrial, municipal and commercial operations, from certain allergenic vegetation, from motor vehicles,

and domestic heating plants, will make it immediately apparent that the degree of a community air pollution problem is proportional to the extent of urbanization and the concentration of industry. Of the 14,000 factories in New Jersey, over 9,000 are located in four of the twenty-one counties. In the same four counties lives 57 per cent of the State's total population. The degree of urbanization can be demonstrated by indicating that 51 per cent of the State's population resides in cities of a population greater than 25,000. In fact, in some areas, city limits join each other."

The New Jersey State Department of Health gives approval to proposed water pollution control projects. Each such project has an engineering estimate of cost. In recent years, the annual total of such estimates has run between thirty million dollars and fifty million dollars. Much of the motivation for this work at the local level — whether municipality or industry — resulted from the steady prodding of your State Department of Health. The waters of the State are being cleaned up. Once we have attained for all of them a fair degree of wholesomeness, it will behoove us to keep them that way. Maintenance can be much cheaper than the kind of basic rehabilitation which we have been going through in recent years.

With the carefully planned program of today's seminar, we will have opportunity to be informed what is being done in air pollution control and water pollution control on the national level, on the state level, and by industry. Many of our municipalities and industries have invested substantial sums to be a good neighbor in the over-all community. Thus they have accepted the philosophy that they are, in some measure, their brother's keeper and are making a significant contribution to public health and good citizenship.

National Air Pollution Control Program

V. G. MacKenzie*

AIR POLLUTION - STATUS AND TRENDS

Contrary to the old saying, there is something new under the sun — as was spectacularly demonstrated to us by the satellite launchings of last year. In a less sensational and more gradual manner, ample demonstration has been given us in approximately the last 15 years of a new era in air pollution. The most striking characteristic of this new situation has been the definite proof of the finite capacity of the atmosphere to dilute and disperse air contaminants over large urban areas. The several episodes in London involving many deaths, that at Donora, Pennsylvania, the continuing troubles with eye irritation at Los Angeles and to a lesser extent elsewhere, and the increasingly widespread agricultural and other economic damage — all these show forcefully that the limited capacity of the air resource is being reached at times in many places. In addition to these obvious effects of excessive loadings of contaminants in the atmosphere, more subtle effects are also suspected. For instance, the fact that death rates for lung cancer in males in the United States increase directly with city size (from 10 per cent above the national average for cities of 50,000 to 100,000 population; almost twice the national average for cities of over 1,000,000) is cause for speculation and further study.

Air is perhaps the most important natural resource to man. Unlike other natural resources, we know of no way to augment the supply which nature brings to each of us. Neither do we know of any way by which the natural self-cleaning action of the atmosphere can be accelerated on any large scale. For the preservation of the cleanliness of the air, only one course is open to us — prevention of excessive contamination.

Within the last 15 years — in addition to the realization of the limited capacity of our air resource, there has developed some greater understanding of the complexity of urban air pollution — the many sources and the roles of invisible gases and vapors as well as visible particles. Also, it has become increasingly apparent that no individual villain, or perhaps scapegoat would be a more appropriate word, can be singled out as solely responsible for the air pollution — neither industry nor the public utility, the burning city dump nor the private automobile or household heating plant. Community air pollution today is associated with many activities

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*Assistant Chief, Research and Development, Division of Sanitary Engineering Services, Public Health Service, U. S. Department of Health, Education and Welfare.

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of our urban population — its increasing industrial activity, greater use of transport, increased consumption of fuel, energy, and materials generally, plus the waste disposal practices of all segments of our urban society.

What, then, of future trends? It seems clear that, barring unforeseen catastrophe, those factors now responsible for community air pollution will have accelerated growth in the immediate future. By 1970, it is expected that our national population will grow by 25 per cent to about 220 million, and our industrial output will approximately double. This will mean not only increase in our standard of living of which we may be justly proud, but also increases in per capita and total consumption of raw materials, energy, and finished products, with an associated potential for corresponding increase in discharge of aerial contamination. Moreover, these increases will occur almost entirely in our expanding urban areas — in general, the same areas now subject to community air pollution.

New Jersey lies in the center of the area of urbanization on the northeastern seaboard, the developing "megalopolis" extending from eastern Massachusetts to northern Virginia. In this area, the ribbon of counties classified as metropolitan is now continuous from Boston to Washington. A developing similar concentration extending eastward from Cleveland through Pittsburgh gives promise of overcoming the barrier of the Appalachian Mountains and consolidating with the eastern seaboard "megalopolis" in the vicinity of New Jersey. The prospective further urbanization of this entire area raises serious questions about the ability of individual cities or communities to cope adequately with their future air pollution problems. It is encouraging that the State of New Jersey is among those states nationally which are in the lead in developing programs for dealing with air pollution.

THE NATIONAL PROGRAM

(a) Objectives:

The Public Health Service has long been interested in air pollution and carried on limited studies relating to it. It has been only since 1955, however, with the passage of P.L. 159, 84th Congress, that legal authority has existed to organize a comprehensive approach dealing with the entire problem. The objectives of the Federal program may be stated very simply:

1. To improve the status of knowledge as to the causes, effects, and means of control of air pollution, and

2. To assist in putting to work on air pollution problems the knowledge we have now and will have in the future.

We in the Public Health Service are surprised sometimes that some people advocate our putting total emphasis on one or the other of these, or sometimes even on a single phase of one of them. In the past our country has achieved considerable success in the control of health problems by using both of these approaches simultaneously. Disease control programs began by applying incomplete knowledge and, as better information was developed through research, it was incorporated in practice. It seems reasonable to us that this dual approach should continue.

(b) Federal Policy:

Federal policy with respect to air pollution has been the subject of clear statements by both the legislative and executive branches of the government. In the preamble to P. L. 159, Congress has declared its policy that the legal control of air pollution is a responsibility of state and local governments and that Federal assistance should be provided through research and technical assistance. In the executive branch, similar policy statements are included in the report (1955) of the Interdepartmental Committee on Community Air Pollution which received the endorsement of the several departments and agencies represented and of the Bureau of the Budget.

(c) Current Program:

The Public Health Service program on air pollution, authorized by the 1955 Act, is now in its third year. Approximately $8.5 millions have now been appropriated under the Act, $1.75 millions in F. Y. 1956, $2.75 millions in 1957, and $4.0 millions in F. Y. 1958.

The major emphasis in the program is on research. Approximately 80 per cent of the available resources is devoted to research and the remaining 20 per cent is used for support of personnel training and the extension of technical assistance on specific problems. From another viewpoint, approximately 60 per cent of the available budgetary resources is devoted to physical science and engineering control studies and 40 per cent to studies on the effects of pollutants on health.

Current research studies pertaining to the physical sciences and engineering control aspects of air pollution fall within several general categories:

1. Development of sampling and analytical methods;
2. Chemical and physical reactions between pollutants;
3. Evaluations of sources of pollution and of pollution levels and characteristics in various geographic areas;
4. Relationships between meteorological variables and air pollution levels;
5. Agricultural and economic effects of air pollutants; and
6. Control methods and equipment.

Time does not permit a detailed reciting of the various projects under way in each of these categories. I would, however, like to mention some which may be of particular interest.

A considerable number of research studies are being carried on or supported relating to the automobile exhaust pollution problem. These include work at our Sanitary Engineering Center, at the National Bureau of Standards, and the Bureau of Mines on improved sampling and analytical methods for quantitative identification of exhaust components, and studies of the reactions occurring between them. Important progress is being made on chromatographic and related procedures for separation and identification of hydrocarbon components of exhaust gases, on the differences in engine exhaust characteristics which are produced by variations in fuel composition, and in the evaluation of catalysts for their potential use in oxidizing unburned hydrocarbons in engine exhaust gases.

The National Air Sampling Network, operated in cooperation with state and local authorities, is now collecting particulate samples from 112 urban and 40 non-urban sites for analysis at the Sanitary Engineering Center in Cincinnati. The results from some 14,000 analyses provide basic information as to the intensity and characteristics of pollutants in American cities. The operation of the Network to date has been limited to particulate matter samples. We expect, however, to initiate soon field trials on methods for collection of gaseous contaminants.

Several complementary studies concerned with design criteria for refuse incinerators are under way at the Sanitary Engineering Center, at the Bureau of Mines laboratory at Pittsburgh, and at New York University. These studies cover the various types of incinerators in common use — from the single chamber unit through the flue-fed types commonly used in apartment buildings in many areas to the large multiple chamber units used in municipal refuse disposal practice.

In that portion of the program concerned with the effects of air pollutants on human health, three principal types of studies are being carried on:

1. Community and other epidemiological studies;
2. Statistical studies of morbidity and mortality and their possible relationship to air pollution indices; and
3. Studies of the toxicological and physiological effects of air pollutants.

Except for the retrospective statistical studies of correlation between morbidity or mortality and air pollution indices — which can be expected only to furnish leads for further investigation — these medical studies will require long-term support to obtain definitive results.

In the initial phases of the health effects studies, emphasis has been given to the statistical studies of the possible relationships between air pollution and human morbidity and mortality and to toxicologic studies to determine the effects of pollutants on experimental animals and biologic systems. These provide leads to, and in some cases are necessary precursors to, further clinical and epidemiological studies on human beings.

Some 20 studies of the toxicologic or physiologic effects of various air pollutants are now being conducted directly by the Public Health Service or supported by contracts or grants. These include studies of the effects of various pollutants on the enzyme systems of the lung and blood, on tissue cultures, on the eye, on pulmonary function, and more generalized toxicologic studies of specific pollutants such as sulfur dioxide, ozone, nitrogen oxides, organic peroxides and hydroperoxides, organic sulfur compounds, and nitro-olefins.

Significant results are already being obtained from some of these. Amdur at Harvard has reported a synergistic effect from a mixture of sulfur dioxide and sulfuric acid mist beyond that which would be expected additively from the individual substances and a greatly enhanced effect from a mixture of sodium chloride aerosol with low concentrations of sulfur dioxide.

Kotin and his co-workers at USC have demonstrated the presence of carcinogenic agents in ozonized hydrocarbons in air and have induced an increased incidence of neoplasms in two strains of mice exposed to high levels of such substances.

Deichmann at the University of Miami has synthesized a series of specific nitro-olefin compounds which are highly irritative to the mucous membranes of man, rabbits, rats, and chickens. Chronic exposure tests, using these substances, are continuing.

Only a few community-type epidemiological studies have been initiated to date. One, being conducted cooperatively by contract with the California State Health Department, is concerned with the possible relation between air pollution and bronchial asthma. A second contract with Vanderbilt University covers a study of health effects in Nashville from that city's type of pollution derived largely from combustion of soft coal and other domestic fuels. A grant to the University of Cincinnati is for a study of the effects of pollution on a group of individuals having serious cardiac or respiratory ailments.

In the two years since the initiation of the Public Health Service air pollution program, several hundred requests for technical assistance on general and specific air pollution problems have been received from state and local government agencies and other organizations. The assistance provided has varied from limited consultation to the assignment of personnel to work cooperatively with state and local agencies. Staff members have been assigned to studies in the States of Connecticut, California, Tennessee, Washington, and Texas, and in Louisville, Los Angeles, New York, Philadelphia, and other areas.

In addition to the direct technical assistance activities of the Service, limited support has been provided for study of local or regional problems of wide significance through demonstration project grants. Such grants have been made to the States of California, Colorado, North Carolina, Illinois, and Indiana, to the City-County Health Unit of El Paso, the Interstate Sanitation Commission, Oregon State College, and the Los Angeles County Air Pollution Control District.

To assist in the alleviation of the shortage of technical personnel trained in air pollution research or control, the Service has initiated short-term training courses through the Sanitary Engineering Center and is supporting graduate level training in universities through grants and traineeships. The short-term training courses are being conducted on a regular schedule by the Cincinnati Center, and were attended by over 500 trainees in the last fiscal year. Grants have been made to ten universities distributed across the country for initial development and support of curriculum and a limited number of university trainees are also being supported in graduate study.

CONCLUSION

If there is any lesson to be learned from recent and expanded efforts to deal with community air pollution, it is that a wide degree of cooperation is needed for success — cooperation by citizens, industry, communities, and all levels of government.

As the facts become known, it is increasingly apparent that the control of air pollution is "good business" for all of us. All the estimates I have seen of even the tangible damages caused by air pollution exceed manyfold the costs of prevention. Furthermore, we all can afford what it takes to control air pollution — in fact, in the future, we may not be able to afford not to control it. We must certainly be alert to assure that air pollution control is not organized and supported so marginally as to endanger the preservation of our air resource essential to the further development of our society, economy, and the further increase of our standard of living.

State Air Pollution Control Program

Miriam Sachs, M.D., M.P.H.*

I have chosen not to discuss the broad general program of the air sanitation program which is the air pollution program of New Jersey State Department of Health. I am sure you know from Mr. Bradley, your moderator this morning, and from Dr. Bergsma's words, that we have a good solid air pollution control program, but I have something of a bit of a scoop for you. This is the first time that in public there will be discussed a project that has been completed by the Air Sanitation Program of the New Jersey State Department of Health. I am going to give you a very brief abstract of the project. The complete project has been written up and published in the August issue of the State Health Department's own publication "Public Health News." The project was conceived by Mr. William Munroe, the program coordinator of the Air Sanitation Program, carried out by him and the final report written by him.

The Air Sanitation Program of the State Department of Health has a very broad responsibility for complete air pollution control programs under the Air Pollution Control Act of 1954. We do have a very specific function of enforcing the codes, rules and regulations promulgated by the Air Pollution Control Commission. But under the act, and as we understand our own role in public health and preventive medicine, we do have the responsibility for surveys on the causes and effects of air pollution and the determination of the kind of air pollution that we have in this state.

We are well aware of the differences in air pollution in different parts of the state. We have not degenerated simply into an inspector force, but have maintained a technical unit which does a great deal of direct assistance work. We have also maintained a unit which we call research and development, which is active all the time working to evolve methods of applied research to learn more about air pollution in general, and essentially about air pollution in the State of New Jersey for which we have the state-wide responsibility.

Those of you who have worked in the field of air pollution, or who have followed the field of air pollution, are cognizant that one of the great handicaps to studies and surveys of air pollution is the fact that there are no methods at all for the determination, collection and analysis

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*Chief, Bureau of Adult and Occupational Health, New Jersey State Department of Health.

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of some air contaminants, and very few standard methods of procedure. In addition, New Jersey, though small and extremely compact, has very many differences in its regional areas. All air contaminants are not present in all parts of the State, or if present, they do not constitute a problem in all parts of the State. However, the one substance which is pretty generally present throughout the State is smoke, or the fine airborne particles which result primarily from the products of combustion.

Accordingly, to test ourselves in a state-wide survey, to see if we could do a geographic distribution of air contamination in the state, the subject of smoke was chosen as our initial effort. This was done, both to give us a measure of the smoke distribution and concentration in the state, and also to test ourselves in the compilation of a great quantity of data, and, what is more important, its subsequent analysis and correlation with conditions as we knew them to exist in the State. Consequently, in February 1956, a state-wide project was started which we hoped would give us the answers to the following objectives:

To obtain an index of atmospheric smoke concentration upon which to evaluate the degree and geographical distribution of smoke in the outdoor atmosphere of the State.

To obtain records of a variation of concentrations of smoke throughout a calendar year.

To develop an index of smoke levels for classifying municipalities on the basis of air sanitation and determining objectively the need for regulation of sources of smoke.

To obtain background data upon which to evaluate the effectiveness of air pollution control measures.

To obtain background data to provide a basis for evaluation of complaints.

I don't think you can say that we were unambitious.

The instrument that we chose for this survey was the AISI Automatic Smoke Sampler. This is an instrument which was developed by the Mellon Institute. It has a motor which pumps air at the rate of one-quarter cubic foot per minute through a one-inch aperture onto Whatman No. 4 filter paper. There is also a timing mechanism which at the end of two hours automatically advances the tape and a new spot is recorded. The instrument was placed inside buildings, as close to the

geographical center of the municipality we were testing as we could find, on a ledge or a table approximately 10 to 50 feet above ground level. An air intake hose went out an adjacent window and was protected on the end by a plastic funnel so that water and other contaminants would not be drawn in. This instrument can be operated automatically for about 20 days, except that you do need someone in the field who agrees to monitor the instrument for you, to make a mark once every 24 hours as to date and time. Otherwise the instrument was fairly self-sustaining with the exception of changing the tape as the rolls became depleted.

When these miles of tape were brought back to the laboratory, the optical density of the spots, which were recorded in shades of gray varying from very light to almost completely black, was converted by a process of light transmission and subsequent calculation into soiling units ranging from zero to 100 per 1000 linear feet of air. These are similar to the COH units which were described by Hemeon when the instrument was first announced. These soiling units are the units that were used throughout the entire study.

We originally placed 40 instruments in the field, selecting our sites throughout the State to give us complete representation of types of communities, topography, population densities, urbanization, industrialization, agricultural and shore areas. This study ran every day for a full calendar year. In the course of the year several of our sites dropped out. That is, the instruments could not be maintained, local people could no longer keep changing tapes or making marks on it. Some of the sites were lost to us by technical difficulties so that when the instruments were finally brought back at the end of the field year and re-calibrated, the data were found to have so many errors in them that they had to be discarded. Of the sites that have been retained in the study, the data are within statistical significance in the area of our operation.

Of the test sites that remained in the study we were very fortunate in that we do have examples of types of communities and types of areas that we wanted to test, as follows: Atlantic City, Boonton, Burlington, Camden, Elizabeth, Jersey City, Lakehurst, Lakewood, Madison, Middlesex, Morristown, Newark, New Brunswick, Paterson, Phillipsburgh, Plainfield, Princeton, Red Bank, Sparta, Trenton and Union.

For graphic illustration of how the smoke levels vary throughout a day, we have shown on page 16 two of the test sites. The upper one is Jersey City, the lower one is Sparta, and these are two-hour readings, recorded over a test week from December 16 through December 23, 1956. The most interesting thing about this figure, and of course we graphed all

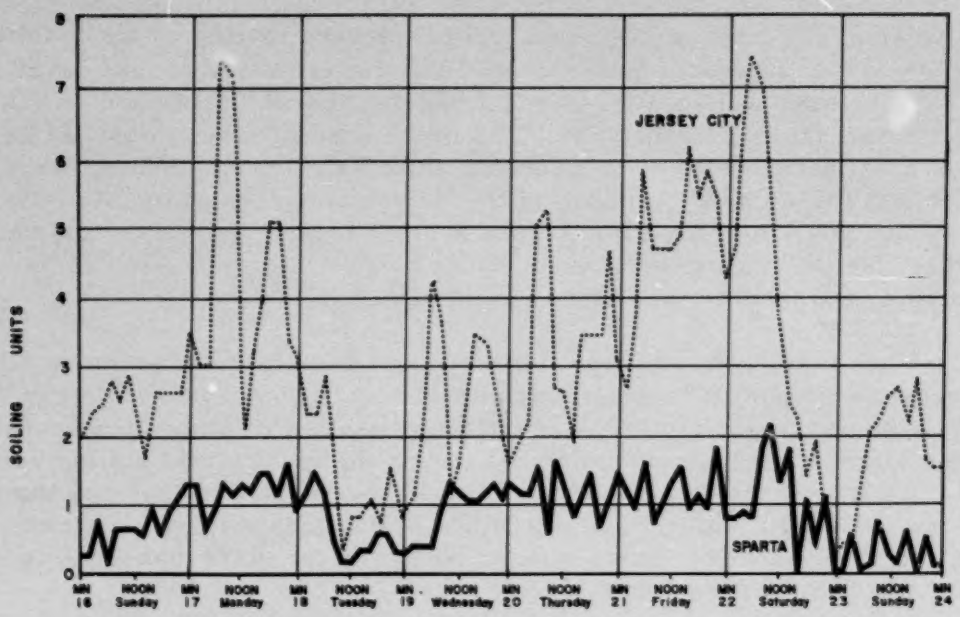

Figure 1 — Level of smoke expressed as soiling units recorded over two-hour test cycles. Jersey City and Sparta, New Jersey, December 16 through December 23, 1956.

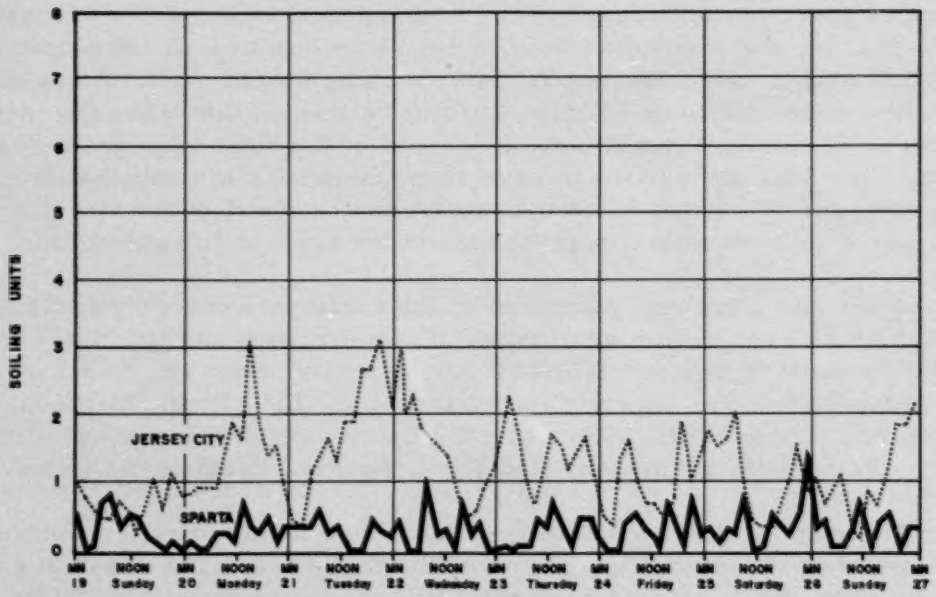

Figure 2 — Level of smoke expressed as soiling units recorded over two-hour test cycles. Jersey City and Sparta, New Jersey, August 19 through August 27, 1956.

of the test sites throughout the state, and these (you will have to take my word for it) are typical, is that this pattern pertains through all test sites. The profile of the graphs, even though Jersey City is much higher and shows much greater soiling than does Sparta, is extremely similar.

Figure 2 is Jersey City and Sparta for the week August 19 to August 27, 1956. Here again you see that during the summer months, while the general level has dropped, the tendency for the graph to maintain similar profile has pertained again through this period as it did for all the others of the 21 sites in the State.

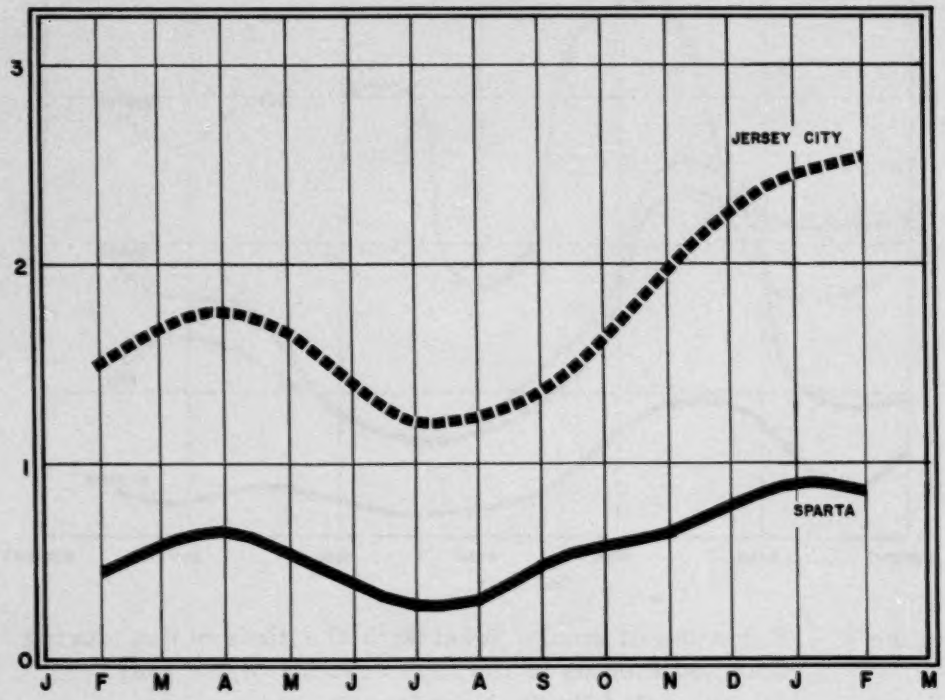

Figure 3 — Monthly average of individual two-hour soiling unit values — Jersey City and Sparta, New Jersey, February 1956 through February 1957.

I think the graphs in Figure 3 are even more startling. It shows Jersey City and Sparta with monthly averages starting February 1956 and going through to February 1957. The soiling units were averaged for the month and the results were plotted, and whereas at every month of the year Jersey City maintained its position at considerably higher

soiling than that in Sparta, the curves are almost identical in shape. Everyone of the 21 graphs, which are in the complete report, when lined up, are so amazingly similar that just from the shape of the graph you could not identify a test site. It is our impression that this general rise in the months of December, January and February is due to increased fuel consumption on the part of everybody — industries, schools, commercial establishments and the general public — and that the decline in the warmer months of the year is due to the fact that less fuel is consumed. All other activities remain practically the same.

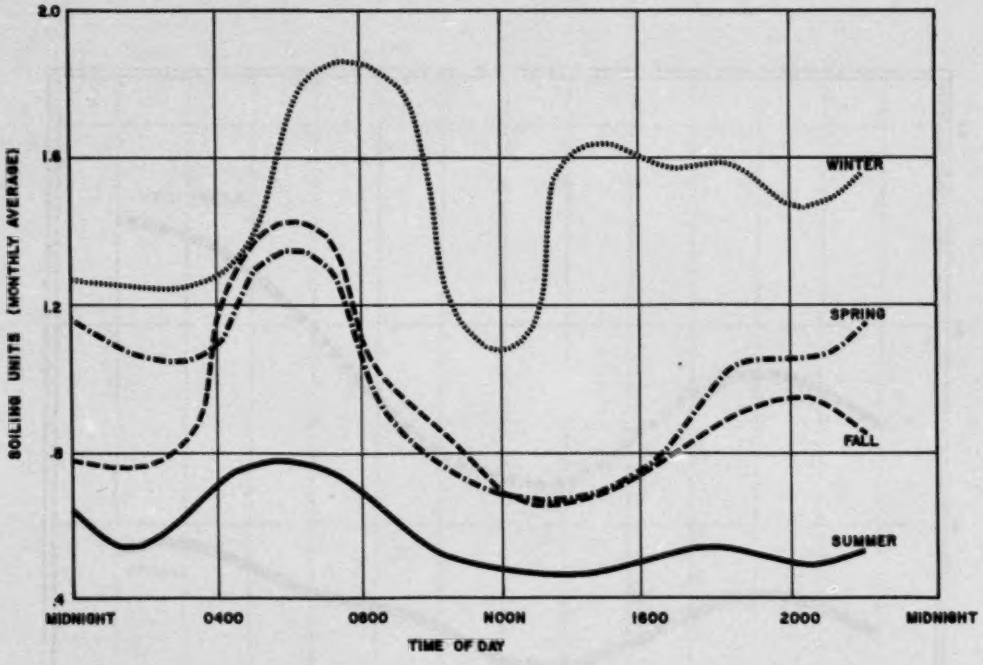

Figure 4 — Variation of smoke level with the time of day during selected months of the four seasons of the year. Red Bank, New Jersey

Figure 4 is another test site, namely Red Bank, New Jersey, and what we have done is to take one month in summer, fall, spring and winter and average its daily and hourly variations. This one reveals the interesting point that whereas the general smoke level varies in the different seasons of the year, the hourly variation starting here at midnight, proceeding to noon at the middle of the Figure and going on to the rest of the day shows an amazingly consistent pattern. The highest smoke level readings are in the early morning hours somewhere between 6 a.m. and

10 a.m.; at approximately noon you get your lowest concentrations of smoke. All graphs of this type of averaging, for each of our 21 test sites, follow this pattern. This has been reported by other observers in other parts of the United States although not for such a long period as the full calendar year. These variations, and this particular pattern, we know is typical of New Jersey, and we feel it is due almost entirely to meteorological factor.

We have had the opportunity on several occasions now to put mobile trailers into the field when we are having a so-called smog incident, and instrument registration records this pattern. The notations of our field people affirm this. When they get into the critical area in the early morning hours, they too experience a smarting of the eyes and discomfort from some of the effects of smog, but along about noon of the day, they call up and say, "Thank goodness, the weather is changing and the stuff is blowing away and clearing out." This has been brought out by this study over the calendar year.

	ADJECTIVAL RATING				
Test Site	Light	Moderate	Heavy	Very Heavy	Extremely Heavy
1. Lakehurst	93.0	6.7	0.3		
2. Sparta	92.8	6.9	0.3		
3. Lakewood	78.6	19.7	1.5	0.2	
4. Princeton	77.4	19.4	2.7	0.5	
5. Morristown	76.3	19.5	3.4	0.6	0.2
6. Madison	73.2	23.1	3.4	0.3	
7. Atlantic City	67.9	27.6	4.1	0.4	
8. Burlington	67.5	26.1	5.7	0.7	
9. Red Bank	67.0	26.9	5.3	0.8	
10. New Brunswick	63.1	26.8	8.5	1.5	0.1
11. Middlesex	61.8	28.2	8.4	1.5	0.1
12. Boonton	59.5	33.3	6.2	1.0	
13. Union	56.9	28.6	10.7	3.1	0.7
14. Phillipsburg	51.4	35.5	11.3	1.7	0.1
15. Paterson	51.3	31.2	12.9	4.0	0.6
16. Trenton	50.0	37.1	10.8	2.0	0.1
17. Plainfield	49.6	33.9	12.5	3.5	0.5
18. Elizabeth	47.9	35.1	12.3	3.6	1.1
19. Jersey City	34.2	41.9	17.3	5.4	1.2
20. Newark	31.6	40.0	19.0	6.2	2.2
21. Camden	25.6	40.8	23.3	8.0	2.3

Figure 5 — Percentage of total soiling unit values in each adjectival smoke level range.

As I said, we ran these miles of tapes every day, 24 hours a day for just about 365 days, and each test site yielded to us approximately 4000 spots. For the 21 test sites that we finally analyzed carefully, we had around 84,000 spots. This type of data is almost impossible to

handle, it's impossible to show anyone. You can't refer to it readily; so one of our first jobs was to reduce data to the point where they could be handled, correlated and mentioned and discussed without having to pull out sheet after sheet of charts and notations. What has been done is that an adjectival rating has been added to the notation of soiling units so that all of the spots that fall within zero to one, actually zero to 0.9, are light; from 1 to 1.9 are moderate; and so on to heavy and very heavy. Readings over four, which would be the very darkest reading or darkest recorded source, are lumped together in the extremely heavy category. In this way we felt that we could average all the spots that came in one category and record them as a frequency distribution against an adjectival rating. The next Figure will show you how this was accomplished.

ADJECTIVAL RATING	Light	Moderate	Heavy	Very Heavy	Extremely Heavy	Smoke Index	Classification
WEIGHTING FACTOR	1	2	4	8	16		
Test Site							
1. Lakehurst	93.0	13.4	1.2			107.6	A
2. Sparta	92.8	13.8	1.2			107.8	A
3. Lakewood	78.6	39.4	6.0	1.6		125.6	B
4. Princeton	77.4	38.8	10.8	4.0		131.0	B
5. Madison	73.2	46.2	13.6	2.4		135.4	B
6. Morristown	76.3	39.0	13.6	4.8	3.2	136.9	B
7. Atlantic City	67.9	55.2	16.4	3.2		142.7	B
8. Burlington	67.5	52.2	22.8	5.6		148.1	B
9. Red Bank	67.0	53.8	21.2	6.4		148.4	B
10. Boonton	59.5	66.6	24.8	8.0		158.9	C
11. New Brunswick	63.1	53.6	34.0	12.0	1.6	164.3	C
12. Middlesex	61.8	56.4	33.6	12.0	1.6	165.4	C
13. Phillipsburg	51.4	71.0	45.2	13.6	1.6	182.8	D
14. Trenton	50.0	74.2	43.2	16.0	1.6	185.0	D
15. Union	56.9	57.2	42.8	24.8	11.2	192.9	D
16. Plainfield	49.6	67.8	50.0	28.0	8.0	203.4	E
17. Paterson	51.3	62.4	51.6	32.0	9.6	206.9	E
18. Elizabeth	47.9	70.2	49.2	28.8	17.6	213.7	E
19. Jersey City	34.2	83.8	69.2	43.2	19.2	249.6	E
20. Newark	31.6	82.0	76.0	49.6	35.2	274.4	E
21. Camden	25.6	81.6	93.2	64.0	36.8	301.2	E

Figure 6 — Summary of weighted adjectival rating percentages, smoke index and classification of municipality.

According to this system of classification, 92.8 per cent of the time, Sparta had extremely clean air within the light category. Interestingly enough, Camden, which in this test survey showed the heaviest soiling, still at least 25 per cent of the time, had air that was as clean as Sparta's. If you add the category of light and the category of moderate, at least 66 per cent of the time Camden, which showed the heaviest soiling, had relatively good clean air which led us very slowly to the next step in our data reduction.

It appeared desirable and practical to reduce these data to a single significant unit of expression which could be applied to a plan for rating municipalities on the basis of air sanitation (smoke). It was felt that such a procedure, in order to reflect truly the problem of smoke, would necessarily have to place emphasis on the higher smoke level ratings. Accordingly, a system of weighting the percentages of time in the five adjectival smoke ratings was applied. It was decided to weight the percentages on the theory that the true significance of air-borne smoke levels increases in proportion to a geometric progression with a ratio two from light to extremely heavy ratings. Therefore, the sum of the weighted percentages represents a total weighted numerical rating which, for the purposes of this experiment, is termed "Smoke Index."

It was felt that the numerical Smoke Index was sufficiently broad to allow for sub-division into five ranges which could be applied as an alphabetical classification to reflect the nature of the air sanitation (smoke) in local areas. Accordingly, the following sub-division of Smoke Index was made to provide five alphabetical classifications of municipalities.

Smoke Index Range	Alphabetical Classification
100 to 124	A
125 to 149	B
150 to 174	C
175 to 199	D
200 Plus	E

This system of rating and this system of conversion of two-hour spots is so logical and the instrument so relatively reliable if you calibrate it and if you watch it, that if this were used as a standard method in different parts of the country, or if we chose to repeat it—and we hope to repeat it in this State again—we would really have comparative data that could be easily recognized and easily discussed.

As we did this experiment, it was extremely costly in man hours, both in the field and in the laboratory, but we have demonstrated that it is a practical method when certain of the technical difficulties are ironed out. We need a little more local cooperation in the field on the maintenance of instruments. We have to make a little more automatic our reading of the optical densities and conversions into units that can be handled, but this is a good and practical method and we hope to repeat the year-long study in the not too distant future. We think that this time we will show that all sites in the State as a result of our air-pollution control activities, while they may maintain the same proportionate rank, will be recorded at lower levels of soiling.

Engineering Control of Air Pollution Problems

W. Brewster Snow, Ph.D.*

In seeking for engineering methods of bringing air pollution problems under control, if we are to avoid becoming bogged down in a search for particular solutions to particular problems, we need to remind ourselves again and again of first principles. Broadly stated these cardinal principles are three in number. The engineer may, first, redesign processes, substituting agents or reactants that give off minimal potential pollutants. Failing this -- and obviously this principle cannot be applied in all cases -- the engineer must look to the removal of potential pollutants from waste-gas streams before discharge. Thirdly, the engineer may plan for discharge of waste-gas streams into the atmosphere at great enough heights to provide dilution to a degree that will insure that pollutants do not reach ground level in harmful or noxious concentrations under any but the rarest meteorological conditions. The solution of any control problem will be arrived at only after the potentialities of each of these principles has been weighed in terms of applicability, efficiency, and economy. In very many cases the solution of choice will comprise the judicious application of all three.

* * *

Patently, the first -- that of process redesign with substitution -- is inapplicable in a great many situations. But there have been notable successes in the application of this method and one is overhasty to reject it out-of-hand. A notable example is the use of steel shot instead of sand for the cleaning of castings to eliminate the hazards of silica dust. Dallavalle[1] and others have suggested that substitution should receive more attention than it has thus far. It may not only simplify and improve a process; it may "even make it more economical."

The removal of pollutants from waste-gas streams is necessarily the most varied field of engineering control procedures. The fact that pollutants cover a range of particle size, from macroscopic to molecular,

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*Chairman, Department of Civil Engineering, Rutgers University.

(1) Air Conditioning, Heating and Ventilation, 53, 75 (September 1956).

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to which we give such names as dusts, smoke, fumes, mists, vapors, and gases suggests immediately that not one but a whole spectrum of removal processes will be required. Some of these today are processes-in-being, and some, at the moment, are little more than suggestions whose ultimate potentialities require extensive research. With regard to those currently available much remains to be done in determining their performance characteristics under a variety of operating conditions, their efficiency measured on some realistic scale, their yield in terms of unit power input, and their capital and operating cost in terms of a suitable unit of waste-gas discharge. Reliable quantitative answers here can only be determined for pilot-plant and later full scale operation.

* * *

For purposes of discussion, the devices currently available to the engineer may be broadly subdivided into: 1. those devices that are capable of removing particulate substances for the waste-gas stream and 2. those that are capable of removal of gases, vapors, and mists.

REMOVAL OF PARTICULATE MATTER

For removal of particulate matter, three fundamental physical principles are employed. The first is differential sedimentation as exemplified by inertial separators such as cyclones and cinder catchers. It is clear that such units find their primary use in removing particles of relatively large diameter -- that is to say, of particles having a small area-volume $\frac{A}{V}$ ratio. Particles in this range respond only to inertial and gravitational forces. Under gravitational forces, they obey Stokes' Law and do not follow stream lines with a gas stream. Removal efficiencies in inertial separators increase with the particle concentration. As a rule of thumb it may be said that for a moderate dust concentration, inertial separators are ineffective in removing particles smaller than 10 microns in diameter. For particles larger than 10 microns, experience indicates that removal efficiencies in the order of 80 to 90 per cent may be expected from properly designed units. The power requirements of inertial separators arise from the need to create high velocity air streams whose deflection creates the centrifugal forces that produce the differential sedimentation effects.

At this point, it seems pertinent to digress to re-state a fundamental point regarding removal efficiencies that has been stated over and over again but does not yet appear to be fully appreciated. Removal efficiencies, like that mentioned above, have generally been stated on a weight basis. A device capable of reducing the weight of particles in a gas stream from 10 grains per cubic foot to one grain per cubic foot is said to be 90 per cent efficient on a weight basis. But this tells the engineer nothing about what percentage by number of particles has been removed, and the particles passing will be the ones of critical size in terms of the ease with which they penetrate the defenses of the respiratory tract.

An alternate method of computing removal efficiencies has been suggested by the American Society of Mechanical Engineers. This proposal is based on a size frequency basis.

> Thus if an air stream contains N_o particles whose mean diameter is D_o, then the product, $N_o D_o^3$, is proportional to the total volume of particles. Likewise, if the effluent stream for an inertial separator contains N particles whose mean diameter is D the product $N D^3$ is likewise proportional to the volume of particles leaving the equipment. The ratio $\frac{N D^3}{N_o D_o^3}$ is a dimensionless ratio expressing the relative volume of particles passing through the equipment. The term $\left(1-\frac{N D^3}{N_o D_o^3}\right)$ expresses the relative volume of particles removed by the equipment. Hence the efficiency of removal is $E = \left(1-\frac{N D^3}{N_o D_o^3}\right)100$.

The second basic principle of particle removal is that of filtration. This is applicable for particles in the range of 1 to 10 microns in which Stokes' Law no longer holds and Brownian Motion can be demonstrated microscopically. The power requirements related to the operation of filter units arise from the frictional resistance of the filter medium and

the associated pressure drop. It is a characteristic of all filters that the pressure drop across them increases with the burden of removed material. Another determinant of filter efficiency is the areal rate of filter flow. Since efficiency is inversely proportional to the number of cubic feet per minute of air per square foot of filter area, the size of these units may rapidly exceed economically feasible proportions.

For removal of particles in the range smaller than one micron whose motion is effected by electrical charge, the passage of an air stream through an electrically charged field has proven effective. Such precipitators deflect charged particles from the air stream to oppositely charged plates. The time required for these deflecting forces to effect deposition of particles becomes a factor in the design of precipitators. Thus, the ratio of the tranverse distance between plates to the longitudinal expanse of the plates becomes a critical factor. In addition, the humidity of the air stream is also a factor with the efficiency varying inversely with the humidity. Efficiencies in the order of 92 per cent on a weight basis are possible with currently available equipment, but these efficiencies depend on the frequency with which the collector surfaces are cleaned.

REMOVAL OF MISTS, VAPORS, AND GASES

There is no sharp line of demarcation between equipment suitable for the removal of solid and liquid particles. Thus, some mists are satisfactorily removed by electrostatic precipitators. For materials that approach molecular dimensions, such as vapors and gases, devices are employed that provide intimate contact between a collecting medium and the air stream. Diffusion along the concentration gradient from air stream to collector is the limiting factor in this type of process. Therefore time rates of flow through units are low and the physical size of such units grows very large.

Three basic types of units have been designed for the removal of mists, vapors, and gases:

1. Scrubbers in which absorption in or reaction with the collecting medium is the key process.

2. Adsorbers in which the gas or vapors is adsorbed on to the surface of the medium.

3. Use of catalytic agents to facilitate the direct conversion of a gaseous pollutant into a non-toxic or non-objectionable form. These latter have been less thoroughly studied but they offer possibilities that make them worthy of more fundamental study. Since many of the catalytic reactions are exothermic, the possibility of recovering usable heat, as a by-product, has been suggested. Meigel[2] has reported on the successful recovery of air at temperatures of 900°F to 1200°F from the catalytic conversion of the exhaust gases from a phthalic anhydride manufacturing plant.

DILUTION

Finally the engineer may resort to the dilution of waste-gas streams into the atmosphere. Over the years, there has grown up an extensive literature, largely empirical in character, on the effect of stack height, of stack velocity, and other factors on the dispersion of stack gases. Bonsanquet and Pearson in England were the first to develop a mathematical model that satisfactorily related the hydrodynamic variables of stack and wind conditions to ground concentration of the pollutant. Bodurtha[3] has reported a method for the rapid solution of the Bosanquet-Pearson equation. This type of development is indicative of a developing ability to construct mathematical models that will in time make it possible to calculate from known data the requisite stack heights and velocities to produce effluent dilutions great enough to assure that specified ground concentrations are not exceeded.

* * *

Repeated reference has been made in the foregoing paragraphs to the need for continuing research in the field of engineering control of air pollution problems. Much of this research will be fundamental in character. We have not spoken of our need for better understanding of the mechanisms of aggregation which, like flocculation in water supply, produces a clumping of particles as a means of facilitating their removal. Likewise, we

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(2) Industry and Power, 69, 47 (1956).
(3) Journal, American Society of Mechanical Engineers, Paper No. 54-A-187 (1954).

have not discussed the promising suggestion of injecting "electrets" into aerosols. The possibility of causing particles to move along a thermal gradient in a manner analagous to their movement along an electric potential gradient, has led to the suggestion of thermo-deposition as a removal process. The suggestion has also been made that adsorptive agents may be injected into a gas stream, collected in a cyclone, and regenerated and recycled.

These potentialities for the future suggest that the engineer will have at his disposal a growing arsenal of methods and processes that can be brought to bear in the solution of air pollution problems. Basic research will be required to prove their range of applicability and relative effectiveness. This, in turn, will require a wealth of solid applied research on the operational characteristics of methods under a variety of temperature, humidity, and weather conditions. Most important, a wealth of data will have to be accumulated on the capital and operating costs of various methods to enable the engineer to design for efficiency within the realm of economic feasibility.

National Stream Pollution Control Program

Gordon E. McCallum*

I am particularly pleased with the subject assigned me today "National Stream Pollution Control Program." Preparing to discuss a few topics under this title has forced me to bone up on the work of my colleagues in industry, the states, cities and interstate agencies. For it is the combined effort of all of these groups that makes up the National Water Pollution Control Program, with the Federal government in a supporting role, as has been made clear by Congress.

More specifically, I have been asked to say something of National policy, objectives, trends, and current programs. Of these four topics, I should like to discuss objectives first.

Recently I have read several lists of objectives of water pollution control. I was not satisfied with any of them, including those I have written myself. In general they do not seem to convey the impression of dynamic, living goals—as, for example, our Federal constitution, often described as a "living document." Objectives must change with the unpredictable and changing future. Many authorities have a real fear of freezing the status quo in the establishment of rigid standards which may not be suited to the future.

Perhaps one of the most general and simplest definitions of objectives is that "water quality be preserved for all legitimate uses." Sensible as this sounds, it is subject to various interpretations and, as an objective, it has in many instances failed to achieve what the public expected.

What is a legitimate use? We have all heard the old question, "Do you want to fish or have your job?" The implication is clear as to which use was legitimate. Economically, how could the fish compete with the job? Twenty years later, however, the citizens are doubly unhappy when, having foregone fishing to keep their jobs, the community fails to land a new industry because of the quality of its water—and these cases are becoming all too frequent. Perhaps someone failed in his objectives. The greatest pitfall in setting a water quality objective or any other objective is not keeping up-to-date in meeting changing conditions and new demands. It is none too early to ask ourselves whether our present programs will provide the quality of water needed by the 60,000,000 additional citizens who will be with us in 1975.

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*Chief, Water Supply and Water Pollution Control Program, Bureau of State Services, Public Health Service, U. S. Department of Health, Education and Welfare.

When perplexed with a difficult problem, one of my superior officers used to reach in his desk for an old reference book. He said that the answer to many of his problems could be found in the sixth chapter and 31st verse of St. Luke, which reads, "And as ye would that men should do to you, do ye also to them likewise." This is a good neighbor policy toward our downstream friends and a thoughtful consideration of future generations. I am sure that most of us agree this would not be a bad water quality objective. Furthermore, as a principle, it has stood the test of time.

National policy with respect to primary responsibility for controling water pollution is well established. Congress has made it clear that this responsibility rests with the states. Consequently, any appraisal of National policy must take into account the policies of the individual states. Those of you who know the Public Health Service are well acquainted with its traditional policy of working with and through the states. The policy and objective of the Service with respect to water pollution are, accordingly, to assist the states through research, technical assistance and grants.

With respect to general trends in water pollution, I would like to make these observations. After a period of near apathy following the virtual conquering of all the well-known water-borne diseases, there is now an awakening in the health profession to the significance of the non-living contaminants reaching our water courses. Contaminants coming from new products used in the home, industry and agriculture present many unknown factors. They are the waste products and the side effects of mid-20th century living. We must remember that 100 million persons drink the same water which, by design or default, carries these vast numbers of new contaminants. And we are not comforted by the fact that our conventional water treatment processes are not always removing them. What may be their toxic effects on man? What may they do to our great aquatic and wildlife resources? Recently, Assistant Surgeon General M. D. Hollis, Chief Engineer of the Public Health Service, posed this question to a group of State officials: "Do we have, in proper perspective, the accelerating build-up of non-living contaminants as a water pollution problem?"

In the field of water resources, transcending water pollution, we may be in a period of the greatest change in the history of this country. In recent years, there have been a number of studies and reports on water by both the legislative and executive branches of the Federal government. Perhaps, the most noted of these is the Report of the Presidential Advisory Committee on Water Resources Policy.

Of greater significance are developments taking place in the states. For example, the National Conference of Commissioners on Uniform State Laws—an organization comprised largely of state officials—has engaged the Law School of the University of Michigan to study basic changes in riparian doctrine with the objective of developing a model state water rights law.

This movement began subsequent to World War II, as a result of the demonstrated value of supplemental irrigation. Confronted with substantial investments in equipment, agriculturalists demanded a clearer definition of their water rights. As a result, the states established study commissions to reappraise their basic water laws and make recommendations to their legislatures. Some states have already acted. Mississippi, for example, has substituted prior appropriation for the riparian doctrine, while Virginia has rejected the proposal.

Particularly significant is the fact that irrigation is a consumptive use of water—much being lost through evapo-transpiration. In contrast, water used by industry and municipalities is non-consumptive—more than 90 per cent being returned to the watercourses. If properly treated, the waste waters from industry and cities can be used and re-used as it flows down stream.

Significantly, in the 17 western states having the prior appropriation doctrine, 92 per cent of the water used is for irrigation and three per cent by industry. In the 31 eastern states, 81 per cent of the water used is by industry and at the present time, three per cent is for irrigation.

The impact of profound changes in water law upon our present programs of water pollution control can only be conjectured at this time.

As Surgeon General Burney told the State Water Pollution Control administrators in Washington last winter, "Whether we like it or not, public policy is being formed and when crystallized, changes completely beyond our control will be in the offing."

A most significant trend is a growing public recognition of the value of good quality water—not alone for an immediate need such as recreation, agriculture, aquatic life or industry—but for the healthful, economic well-being of the region. The position that we cannot afford to control pollution is giving way to one of finding it imprudent to squander our greatest natural resource by using it but once, soiling it beyond redemption, and throwing it away. Our continued national growth and

security demands that water be made to do more and more work for more and more people by being used over and over again.

When speaking of trends, we engineers tend to think of where we are going—is pollution being controlled or is it increasing? Unfortunately, we are not able to answer this question in a satisfactory manner. Congressional committees have criticized us on this score. State officials have had similar experiences. We do know that for the country as a whole, municipal waste treatment has never kept pace with urban growth. Our information on the industrial waste problem is most fragmentary. Our knowledge as to what is being done by industry—and it is considerable—is about as scanty. The public knows far less and often believes the worst.

The Report of the Presidential Advisory Committee to which I earlier referred had this to say about information on the quality of the Nation's waters, "The problem of pollution of streams by municipal and industrial wastes is becoming increasingly serious. Measurements of this aspect of water quality have been so sparse and of such short duration that the available information is inadequate to meet existing needs." As engineers and administrators, we are finding it increasingly necessary to be better armed with the facts.

The public views the current water pollution control program in terms of what industries and cities are doing, or failing to do, in keeping pollution from our waters. Accounts in the press indicate that the public is impressed with such projects as the one American Cyanamid Company is completing here at Bound Brook, with its unique feature of serving neighboring communities. People seem to be less concerned with the roles of the State or Federal government, a possible exception being that of regulatory action. We find this same attitude reflected in Congress on matters of legislation and appropriations. They want to know just how this or that activity will get something built or prevent pollution. It is quite clear that the respective roles of cities, industries, states and the Federal government in the national water pollution control program are not well-understood by either the public or many of its elected officials. In this regard I should like to quote from a recent statement by Kenneth Watson, President of the Federation of Sewage and Industrial Wastes Associations:

> "Waste treatment is an area which the average citizen takes for granted. His health and welfare are directly dependent upon the ability of the people in the waste control field to condition the nation's wastes so they do not destroy him. Apparently,

the Federation and every other organization and agency concerned with this field have done a poor job of telling this story. There must be a way to get this story across."

As a prerequisite to getting our story across to the public, we must have good communications among ourselves. This seminar today is an example of good communications, and I appreciate this opportunity to give you a brief report on what we are doing in the Public Health Service under the legislation passed two years ago.

Our research authorization has been broadened so that it leaves little if anything to be desired. We have not yet been able to implement all of its provisions such as research fellowships. We have, however, considerably increased our own research efforts at the Robert A. Taft Sanitary Engineering Center in Cincinnati. We are also assisting several investigators with research grants.

The states and interstate agencies are using Federal program grants to extend and strengthen their programs to meet new problems. It is most encouraging that at least 25 states and some interstate agencies have initiated or expanded programs of research.

Congress included in the Act an authorization to collect and disseminate basic data on the quality of the nation's waters. A cooperative program with the states comprising an inventory of facilities and a sampling network of water quality has been initiated. Hopefully, this will give our successors a better picture than our predecessors furnished us.

Related to our basic data program is a study of the economics of water pollution, for example, what does pollution cost and what must be spent to control it. We do part of this work with economists and engineers on our staff and part by university contracts.

We are encouraged by the results of our conferences on interstate pollution problems. The conference procedure was added to the Water Pollution Control Act upon recommendations of a number of state officials. Dr. Bergsma, your distinguished Health Officer, worked closely with the Congress on that legislation.

We have now conducted seven such conferences, involving some of the largest cities of the country. In all cases, agreement has been reached on time schedules for corrective action.

Federal grants to speed up lagging construction of municipal treatment as an integral part of water pollution control have been made available for

the first time. The record indicates, that as an incentive, they have accomplished what Congress intended. Contract awards for calendar year 1957 were 40 per cent higher than the previous five-year average—this despite a most unfavorable bond market. The construction level in 1957 was $351 million. This is good but the cities of the nation need to spend at least $500 million per year to keep up with the pollution load.

A few states, also recognizing a lag in this field, are providing financial aid to municipalities—some as a result of the Federal grants.

A major portion of our effort is in technical assistance to states and other jurisdictions of government on new and special problems. These services rendered by the Taft Center at Cincinnati and by our regional offices, cover a number of activities. While they are not readily identifiable as our own accomplishments, we consider them most important.

In addition to the sanitary engineering type of problem, we are now beginning to be consulted more on matters of state laws, regulations, economics, finance and interstate compacts—another indication of changes that are affecting the water pollution field.

The Public Health Service not only provides consultant services to others but is the recipient of some very fine consultant service itself.

The Water Pollution Control Advisory Board, to which Dr. Bergsma was twice appointed by the President, meets periodically to advise the Surgeon General on matters of major policy. Between meetings, individual members of the Board are called upon frequently.

Another group which helps us keep abreast of the problems in industry is the National Technical Task Committee on Industrial Wastes, with which our moderator has long been associated. Dr. Richard Hoak, 1958 Chairman, was invited to report on the activities of the Task Committee at the meeting of the Water Pollution Control Advisory Board last month. We are working continuously with such organizations as the Association of State and Territorial Health Officers and the Conference of State Sanitary Engineers. We frequently call as consultants officials of state and local governments and of industry.

It is through these contacts and associations that we try to keep the proper perspective of our supporting role in the National Water Pollution Control Program.

State Stream Pollution Control Program

Robert S. Shaw*

The constructive stream pollution control program of the New Jersey State Department of Health is almost 60 years old. The basic problem of controlling stream pollution in this state always has dictated a constructive program. The early efforts to build a program, based exclusively upon police powers and penalties, failed. The early legislation of 1876, 1878, 1888 and 1893 gave way to the constructive laws of 1899. These laws, amended and supplemented from time to time, remain as the basic control statutes in New Jersey today.

Each decade has required tailoring of administration of the program to the changing times. The first 25 years of the program were marked by prolonged litigation which provided the court decisions so important to the future of the program. Litigation has become almost a procedure of the past. The time-consuming nature of such procedures no longer burdens the administrative and technical personnel engaged in the program. Theirs is the legacy of the pioneers who built the anchorage for today's program.

The objective of the stream pollution control program of the New Jersey State Department of Health is to assure abatement of undue present pollution, control of present and future pollution, and prevention of future undue pollution. More specifically this means:

1. The abatement of pollution which, in the language of the statute, causes or threatens injury to inhabitants of the state either in their health, comfort or property.

2. The surveillance of the operation of sewage and industrial waste treatment and disposal works so as to assure:

   (a) Effective operation
   (b) Expansion when needed
   (c) Intensification of treatment when needed.

3. The survey of streams to determine existing conditions and to provide a basis for future control measures.

4. The routine continual sampling and observation of streams throughout the State.

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*Assistant Director, Division of Environmental Sanitation, New Jersey State Department of Health.

5. The guidance of municipalities, industry and others so as to avoid undue pollution in the future.

The problem in New Jersey is dominated by the following more important considerations:

1. The population density of most of New Jersey now is such that it is almost impossible to discharge polluting material to any intra-state waterway without causing or threatening injury to someone downstream.

2. New Jersey is the home of a very wide diversification of industry producing almost every conceivable type of industrial waste problem.

3. Sixty per cent of the area of New Jersey is potable watershed.

4. Recreation, especially bathing, along the ocean beaches and in our upland lake regions has become a tremendous business asset to the State.

5. Vast areas of our surface waters support a tremendous shellfish industry.

The present problem then is to make adequate provision for the aforementioned and concurrently to assure proper disposal daily of several hundreds of millions of gallons of domestic sewage and a like quantity of industrial wastes.

The New Jersey State Department of Health is endeavoring to keep pace with the changing scene in its administration of the stream pollution control laws of this State. The Department realizes that its edicts must be reasonable. The Department appreciates that there are important economic considerations in this work. Undue pollution of a stream may mean a threat to public health; it may mean property damage; it may mean such discomfort as to cause displacement of persons. It can mean economic ruin of a neighborhood, a valley. On the other hand any pretense at maintaining or restoring pristine purity of a stream in a densely populated or industrial area is folly, doomed to failure. Between these two extremes is the objective of the State Department of Health in New Jersey. Determination of the happy medium is the continual problem. The answer of 25 years ago is not the answer today. Today's answer will not suffice 25 years hence.

New Jersey will continue to grow. Thriving industry will continue to be necessary for the economic welfare of the State. We shall need more

water supply. We shall have more leisure time. We shall have more bathers, more fishermen. We shall have more sewage and more industrial wastes and we shall have less water in our streams. We shall have a continually mounting problem.

It has taken much more than the exercise of police powers to effect the accomplishments to date. Fortunately the stream pollution control laws of New Jersey, although by design primarily police instruments, are sufficiently broad to permit of constructive action by the State Department of Health. The statutes leave much to the opinion of the Department. They delegate to the Department the perogative of establishing rules, regulations and conditions under which structures such as sewers and treatment works may be constructed and operated. It is incumbent upon the Department to be reasonable in its analysis of stream pollution problems and in the establishment of administrative tools for implementation of the statutes.

It takes much more than the wielding of a police club to bring about such major stream pollution control projects as we shall see here today. Such projects require extensive scientific research, painstaking engineering planning and design, economic and policy decisions by company management and a mutual respect as between company management and staff and the State Department of Health. The Department has contributed to this accomplishment by being reasonable in appreciating the time element involved and by being realistic in establishing the conditions under which it approved the construction and future operation of the plant. Throughout, however, the Department has gained and retained the respect of company management and staff by being firm in the discharge of its responsibilities to the citizens of the State, particularly the lower Raritan Valley. Thus it is demonstrated that the stream pollution control program of the Department transcends by far the mere exercise of a police power. The same applies perhaps even to a greater degree in relation to the tremendous multi-municipal sewerage projects of the Elizabeth Joint Meeting, the Rahway Valley Sewerage Authority, the Bergen County Sewer Authority, the Middlesex County Sewerage Authority and the Somerset-Raritan Valley Sewerage Authority.

The municipalities and industries of this State have been constructing stream pollution control projects at the rate of $30,000,000 to $50,000,000 per year in recent years. The estimated cost of projects approved by the Department during the current fiscal year is more than $46,000,000. These are not paper projects—they are real. Almost without exception their construction is imminent.

Today there are approximately 425 sewage and industrial waste treatment plants in operation in New Jersey. The number is growing continually

even though many plants are being abandoned as a consequence of the big Authority projects. With two or three exceptions which are operating under Court orders to construct, all municipalities which have sanitary sewer systems now have sewage treatment plants.

One might be inclined to conclude that all is well and that the stream pollution control program in New Jersey could best be filed and forgotten. Unfortunately such a conclusion would overlook some important facts as follows:

1. Thirty per cent of the sewage treatment plants in New Jersey are more than 25 years old. These plants become overloaded, antiquated and they do wear out.

2. Experience has demonstrated that only continual regular inspection by experienced engineers will assure good sewage and industrial waste treatment plant operation.

3. Many of the newer treatment plants are producing unsatisfactory results. We do not know why. We must determine why and see that corrective measures are taken. The same engineers who will make these determinations by field observations and testing will be examining plans for future plants and they shall learn from the errors of the past and from the means employed to correct those errors.

4. Even though we have a good licensing law we are failing to get good plant operation in too many instances. Again we do not know all the answers. We must try to find them.

5. There remain scores of industries (fortunately mostly small ones) which are providing little or no treatment of industrial wastes which are polluting our streams.

6. Realty developers have learned to build sewers and sewage treatment plants rather than inadequate individual sewage facilities. These little plants, many of them packages, bring many design and operating problems. The competition among the equipment manufacturers for this business is sharp and it produces problems because of a continual flow of new designs.

7. The citizens of the State are demanding cleaner streams.

8. New Jersey is continuing to grow.

The stream pollution control program as now constituted in the New Jersey State Department of Health is adequate to cope with the problem in New Jersey. The Department needs the support of an enlightened public opinion, cooperative legal support, a sympathetic judiciary, a staff of well trained and experienced sanitary engineers supported by a competent clerical staff with adequate working conditions including office space. Last but not least, the Department needs the patience and foresight to continue to police, plan and persevere in its determination to be constructive.

Toxicity Studies in Stream Pollution Investigations

Charles E. Renn, Ph.D.*

We study the action of wastes, treated wastes, and waste bearing waters on aquatic animals for several good reasons. First, the action of wastes or treated wastes upon the population of our larger streams are important criteria in the choice of new plant sites and in the selection of manufacturing processes at new sites. The larger chemical manufacturing companies have been particularly active in such studies. It is now common practice to analyze the economics and ecology of the waters of the region of proposed plant constructions and new manufacturing processes to discover if the waters will accept the wastes without damage to recreational and commercial fisheries, to esthetic values, and even to anticipated uses. This has become necessary. Our larger and more mobile population has raised the recreational values of surface waters beyond anything anticipated 50 years ago. Practically all states have laws and enforcement agencies designed to protect the recreational values of surface waters.

A second important use of biological investigations of wastes grows from the need of existing plants to diversify and to expand operations. A successful plant almost invariably expands. In our economy, where there is increasing demand for new products, it is almost axiomatic that a successful plant will undertake the manufacture of materials for which it was not initially designed. Expanding plants mean more people living, working, and playing along the industrialized streams, estuaries and lakes. On the other hand, we cannot change the character of the receiving waters themselves. In this case, it becomes necessary to know what must be done to preserve and improve downstream waters.

Third, waste treatment processes and waste abatement regimes are often necessary to meet the requirements of regulatory bodies and laws designed to protect the health of communities. We must be certain that meeting imposed or mutually derived standards will actually do what we hope.

In all of this thinking there is the general assumption that a waste receiving stream which supports a wide variety of aquatic animals and plants can also be used for domestic and industrial purposes with a minimum of treatment. This is not strictly true but it is a good working rule. It would certainly be difficult to argue that an offensive waste receiving stream, in which few or no animals live, is the most valuable stream, although the

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*Professor, Department of Sanitary Engineering and Water Resources, The Johns Hopkins University.

dollar value of such a system for disposing of a number of wastes may be very high. The public does not accept this.

The tests that we use to examine the effects of industrial wastes upon water must approximate the conditions of the projected environment. This makes it impractical to apply anything comparable to a universal test. We cannot, for example, extrapolate data on the action of a refinery waste upon oysters in cold, clear, northern waters to the same species of oysters growing in warmer, more turbid waters along the southern or Gulf coast. It isn't practical, either, to take data, developed in studies of the commercial shrimp, for design of waste disposal criteria for streams containing small mouthed bass. It is unnecessary to say anything about the very large amount of recorded data on the beautiful but tough domestic goldfish, a substantial part of which was developed in distilled water solutions. These may have application to the somewhat unusual situation of glass-lined distilled water lakes and rivers stocked exclusively with goldfish.

The first design information for biotesting that we need is an approximation of the surface water system into which the wastes are going to be discharged. Biological testing is tedious and very time consuming, and there is rarely the opportunity to analyze properly all of the factors that should be considered. An investigator is forced to limit himself to the more obvious and critical parts of the problem.

Despite these limitations, a biological testing program can yield extremely valuable information. Wastes which are damaging show themselves quickly in the death records of the test animals. The application of such information can avoid catastrophic fish kills that have been associated in the past with low waters and with waste surges. This step alone can be valuable.

The second set of information that is needed is a comprehensive statement of the waste characteristics and the range of variation in quality and quantity. Wastes from pilot plant operations may differ substantially from those produced in the industry itself but if the principal characteristics of the waste can be known, tests can be especially adapted to examine the more critical aspects of the action of the waste stream upon the receiving waters. Some wastes, for example, show greater biological activity in their undissociated form. Others are more active as ions. These are commonly pH sensitive wastes and it becomes important to know what the pH range of the receiving stream will be so that suitable test conditions can be set up. If there is any background on the physiological action of the wastes, this may be translated to studies with aquatic animals. Wastes that yield cyanide,

for example, almost universally act on the labile iron in enzyme systems of a wide range of plants and animals. The technical and research departments can frequently furnish much valuable physiological information.

Finally, in a practical test program we are always faced with problems of logistics, with availability of suitable quantities of wastes, their handling, shipping, and storage. Sometimes only a few ounces of a new waste are available. At other times, the biological action of a waste may be so weak that hundreds of gallons may be necessary to carry out a satisfactory test. The interpretation that can be made from tests where limited quantities of wastes are available must always be conservative, but even the simple knowledge that a waste will or will not kill fish or aquatic insect larvae in concentrations ranges many times above or below that existing in the proposed receiving waters, can be very valuable.

The statistical bases of biological tests have been worked out rather elaborately. Biotests have been used in drug standardization for many years and the probit method has been highly refined for this application. Ideally, probit analyses should be employed in biological tests of wastes. Practically, it has certain limitations. It is almost impossible to secure a standard population of aquatic test animals. The fish population from a hatchery pond, for example, is not in any sense comparable to a standard population of white rats or mice. Such a population is intrinsically more standardized than insect larvae or nymphs collected from a stream bottom. In actual work we have to concern ourselves with the reaction of a weaker fraction of the test population. The quantities of animals that can be used are limited by collection facilities and by the success with which they may be stored and kept in the laboratory. The transportation of animals from hatcheries or from streams to the laboratory becomes a very significant limit to the quantity and types of organisms that may be used.

In biological testing it is always desirable to have some secondary criterion for judging an effect. The record of death has statistical meaning but if the animals show other reactions before death this meaning may be extended and reinforced. For example, in much of my own work on the tolerance of fresh water fish to industrial wastes and to treated wastes, I use the blackhead or fathead minnow, Pimephales promelas. This minnow has many good properties for biotesting. The adult minnow is small, and groups of this fish handle well in the aquarium. They live for long periods; feed, and grow in laboratory stock tanks. They don't jump out of shallow tanks. (Many other fish do.)

Blackhead minnows are raised commercially for bait and are available along the East Coast and through the Middle West in many private hatcheries. They may also be taken from ponds and from some shallow streams.

These are fish of medium sensitivity, comparable to the bluegill sunfish, Macrochirus maculatus, another commonly used test fish. Over and above this, they show two very useful reactions. First, they have a characteristic color response. Many fish do, but the behavior is marked in the blackhead minnow. When they are kept in the dark, they take on a dark color. When they are placed in the light, they become lighter. Unhealthy specimens or animals which are reacting to the waste can be picked by abnormal coloration. In a toxic waste system it is quite common that a few members of a test population will darken or remain dark when other members begin to bleach. This difference may show several days before first deaths occur. It is possible to readjust concentrations and save substantial amounts of time in a testing program by noting the early color behavior. A second useful characteristic of blackheads is their schooling tendency. When a test population is placed in a new environment, the fish explore their surroundings vigorously. In this exploration they show a marked schooling tendency. All of the animals will head in the same direction and will swim together in a school. During the first few hours in a new tank, a group will spend most of its time in the bottom corners of the tank, shifting from one quarter to another as their fish whims change. After a day this reconnaisance is less marked, though the group will commonly stay together. If a toxic material is present, however, the schooling tendency is quickly lost. Animals will swim at random and many of them will swim near the top of the tank. Observations of schooling behavior is very useful in anticipating the course of a test.

Inevitably, different investigators will prefer different types of tests. Experience with different animals and different test conditions yields information on the limitations of the technique and any worker is inclined to have more confidence in a method that he has used for some time. It is remarkable, in the face of this, that different investigators so frequently agree on the concentration ranges for tolerance of known toxic materials.

Perhaps the most difficult factor to analyze by biotesting is the protective adjustment of the aquatic population itself. All aquatic environments vary greatly from season to season and from day to day. A successful animal must adjust itself to a wide range of temperature, dissolved oxygen, carbon dioxide tensions, pH, turbidity, and other aquatic quality factors. Without this flexibility it could not exist. A critical biological testing system should discover the range in which these adjustments break down. At low temperatures, for example, many fish are tolerant of

extremely low concentrations of dissolved oxygen and at such temperatures respiratory toxins may have little effect. At elevated temperatures or at lower pH, where the dissolved oxygen concentration is a more critical component of the environment, the action of waste containing components that act on the respiratory system may become much more significant.

In this sense biotesting as part of the waste abatement program and waste treatment design has to be fitted to the special aquatic environment of the plant site. We can transfer obvious similarities to comparable sites, but general comparisons are unreliable; each section of a stream is a different world for the animals in it. We can satisfactorily establish the extreme conditions necessary for groups of organisms in spite of this. These limits alone are useful data.

The Cyanamid Story at Bound Brook

James C. Lamb, III*

This part of the seminar is to review, in general, the stream pollution problem in the Raritan Valley and to summarize the steps which have been taken over the past 20 years by American Cyanamid Company to cope with this problem.

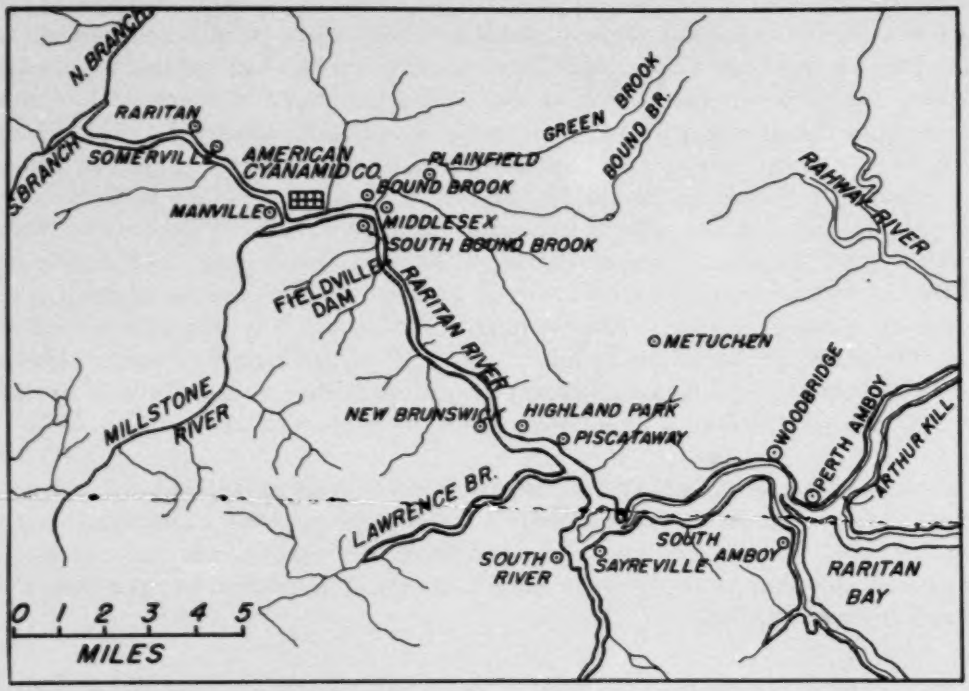

Figure 1 — The Raritan River

It has been pointed out that stream pollution problems on national and state levels have been caused by rapidly expanding populations and phenomenally rapid industrial growth. The Raritan Valley area is one of the most rapidly growing regions in New Jersey. Its population has increased by about 60 per cent over the past 25 years, which is about twice as fast as the over-all rate for the State. That area of the Valley which is shown in Figure 1, bordering the Raritan River between Somerville and Raritan Bay, has increased at an even faster rate.

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*Sanitary Engineer, American Cyanamid Company, Bound Brook, New Jersey.

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The Raritan River receives pollution along its entire length. The pollutional materials originate from many sources including, of course, natural pollution which is present to some degree in any stream, even in the absence of habitation. Along the upper reaches of the river, not shown in Figure 1, the runoff from farm lands adds organic materials, nutrients and other potential pollutants to the stream. In the area between Somerville and Raritan Bay, in particular, the river has received substantial quantities of municipal and industrial wastes for many years.

Many years ago the small quantities of municipal and industrial wastes from the then sparsely populated area could be discharged without treatment of any type and assimilated by the river with little or no adverse effects. As in countless other areas of the country, stream pollution problems arose along with increases in population and industrial concentration. In the 1920's and 1930's, the rapid municipal and industrial growth in the area resulted in increased discharges of organic materials into the river, finally reaching a point where the river suffered radical deterioration in quality. The stream pollution difficulties were rendered unusually critical by the extremely low flows which prevail in the stream during dry periods of each summer. Accordingly, a cleanup was started during the 1930's on all sources of pollution in the Valley. Along with municipalities and other industries, Cyanamid participated in this program and in the late 1930's constructed a treatment plant at a cost of about $500,000.

A sump and pumping station were constructed to deliver all plant wastes to a lagoon of approximately 19,000,000 gallons capacity. In this basin settlable materials are removed from the waste, but the main function of the unit is to provide equalization of acid discharges prior to neutralization with lime.

After neutralization, the wastes flow through a 60,000,000 gallon lagoon, shown in Figure 2, which serves a dual treatment function. Materials precipitated from the wastes during neutralization are removed by settling in this basin. In addition, the three-to-four-day detention period allows time for the various colors in the influent wastes to intermix, resulting in discharge of a uniform, light tea-colored effluent. The dredge, which may be seen in the background, is used periodically to remove solids accumulated in the basin. This treatment plant has been operated continuously since 1940 at a current cost of about $400,000 per year.

During the 1940's, continued and rapid growth of the area shown in Figure 1 resulted in the discharge of additional organics into the stream,

in spite of treatment which was being provided by many municipalities and industries. Once again the quality of the stream suffered radically and it was necessary to plan for additional removal of pollutional materials from all sources before discharge into the river.

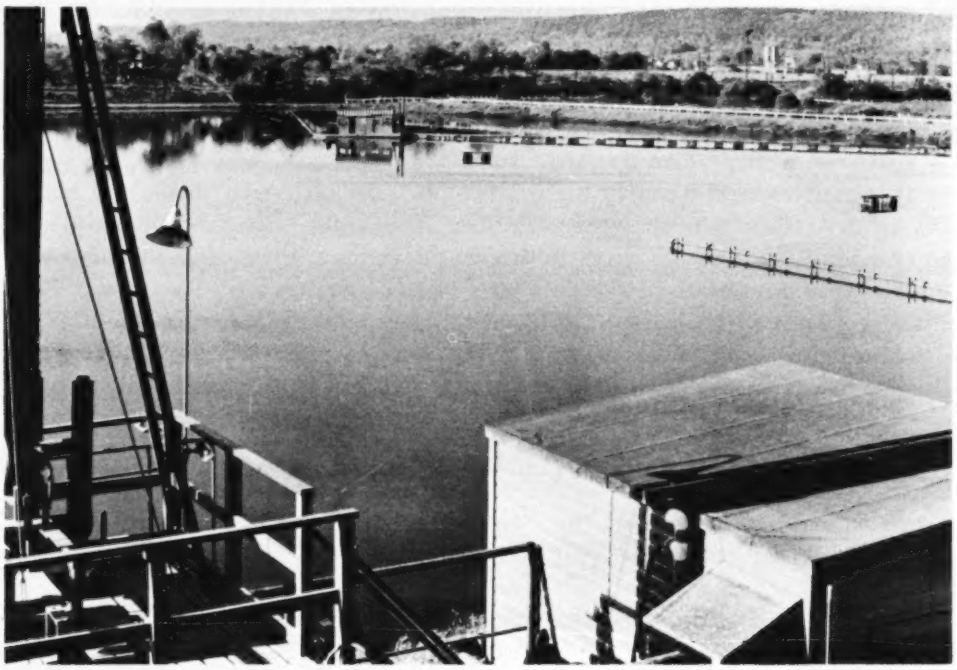


Figure 2 — A 60,000,000 gallon lagoon for waste treatment at Cyanamid's Bound Brook, New Jersey plant.

THE NATURE OF CYANAMID'S PROBLEM

The manufacturing area of the Bound Brook Plant covers about 100 acres (see frontispiece). Production at this location involves manufacture of a wide variety of chemicals including pharmaceuticals, rubber chemicals, pigments, plastics, several hundreds of dyes, and large tonnages of "intermediate" chemicals which are subsequently used by other plants or other companies for production of finished products.

All liquid flows from the plant are discharged into one sewerage system. These flows include process waters from the manufacturing operations, cooling waters, sanitary sewage and storm runoff, totaling about

17,000,000 gallons per day currently. Due to the age and complexity of the manufacturing area, it would not be feasible to segregate these flows for separate treatment and disposal. The wastes from many of the individual manufacturing operations would be difficult to treat. Taken together, the hundreds of wastes discharged from all manufacturing areas present an extremely complex problem in wastes treatment.

Prior to treatment, the waste, which contains a variety of acids, has a pH of 2.0 and an over-all acidity equivalent to about 40 tons per day of sulfuric acid. The organic load discharged from the plant varies widely in quantity and quality but averages approximately 40,000 pounds per day of five-day Biochemical Oxygen Demand. This is roughly equivalent to the load which would be discharged from a city of 200,000 to 250,000 people or about one-and-a-half times the size of Trenton. However, the waste is much more difficult to treat than an equivalent volume of municipal sewage because it contains many complex, synthetic organic compounds and most of the organic materials are present in dissolved form.

Less than 10 per cent of the organic (BOD) loading is removed by the existing treatment plant which has been described earlier. This is in spite of the fact that iron and aluminum compounds in the waste, combined with three to four days of settling following neutralization, make this an extremely efficient "chemical" or "intermediate" treatment plant. Of course, this is no reflection on the installation because it was designed originally for neutralization of acids, removal of suspended solids and equalization of colors. It is entirely successful in accomplishing these purposes.

A waste which contains only 300 parts per million of BOD, mostly dissolved, is much too dilute for any known practical chemical treatment procedures, and it is necessary to turn to biological types of treatment as the only hope for practical removal of organics. Of course, with variable concentrations of complex organic compounds, this leads immediately to the question of whether the waste can be treated by conventional biological treatment methods or whether its character may require drastic modifications in usual treatment procedures, or perhaps even preclude this type of treatment altogether. This was the first of a long series of questions which the Company has had to explore in detail over the past several years.

PRELIMINARY STUDIES

In 1949, the Company sent samples of its wastes to the Lawrence Experiment Station, in Massachusetts. These samples were studied under laboratory conditions and it was found that they could be treated biologically by the trickling filter process. Of course, this conclusion only referred to those specific samples. The next logical question was whether the waste could be treated by biological methods on a day-to-day basis, in spite of the varying quality of materials discharged from the manufacturing plant.

In 1950, the Company built a small trickling filter pilot plant at Bound Brook to explore this question. Extensive studies indicated that the wastes could be treated biologically on a continuous basis, but that the standard methods of biological treatment could not be expected to perform satisfactorily. Since the characteristics of the wastes required special modifications in known biological treatment processes, the Company then was faced with two basic questions:

(a) What type of biological treatment process should be used?
(b) How large should the plant be?

In 1953, a large pilot plant was constructed to provide the answers to these questions.

PILOT PLANT INVESTIGATIONS

During the past five years, the Company has thoroughly investigated two basic types of biological treatment:

(a) The trickling filter process
(b) The activated sludge process.

Actually, of course, we have examined in detail many modifications of each of these processes but they will not be discussed in detail here because of time limitations.

The results of several years of extensive pilot plant operations indicated that both processes worked and either could be used for treating the Bound Brook wastes. The trickling filter process was found to be

capable of removing 50 to 75 per cent of the pollutional materials (BOD), depending on the flowsheet selected for the plant and, of course, the number and sizes of units.

The activated sludge process was found to be better for treatment of these wastes because it provided a higher degree of treatment (BOD removal), the degree of treatment was found to be more consistent on a day-to-day basis, and the cost of construction was substantially lower than for trickling filters. The past three years of continuous operation of many pilot plants, and operation of the full scale plant to date, indicate that the modified activated sludge process, which was selected for this treatment plant will be remarkably reliable and insensitive to shock loadings resulting from variations in waste strength or quality.

Figure 3 shows the flowsheet for a typical activated sludge plant. The waste to be treated and the "return sludge", which consists for the most part of living bacteria and other organisms, are introduced into an aeration tank. This tank is large enough to provide a detention period for the mixture of wastes and active biological sludge varying from one-half hour to several days, depending on the characteristics of the wastes. The aeration serves two functions: (1) it mixes the sludge and the wastes so that the organisms and the organic materials, which they use for food, come in contact with each other and (2) it provides oxygen which is required by the organisms during oxidation of the food materials. The

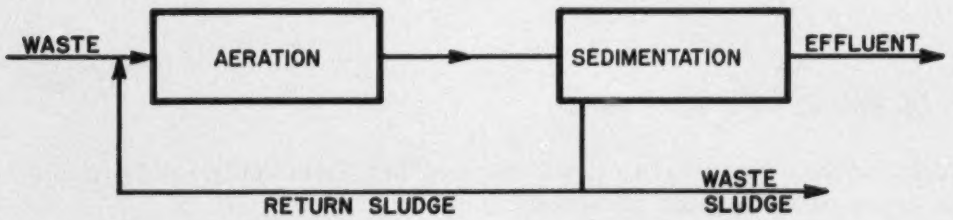


Figure 3 — Flow sheet of a typical activated sludge plant.

sedimentation basin is used to remove the sludge from the liquid through settling. Most of the sludge is returned to the process for treating the waste then entering the aeration tank. The "excess sludge" manufactured in the process usually must be treated and disposed of by other methods.

TREATMENT PLANT DESIGN

Figure 4 is an architectural rendition of the new plant which went into operation on May 21. This facility will treat the effluent from the existing treatment plant, described earlier, which will continue to function as it has over the past 18 years. The flow is transmitted from the 60 million gallon lagoon through a 48-inch pipeline to a 36 million gallons per day (MGD) pumping station, which is located in the pipe gallery under the main building. The wastes then are pumped into the six aeration tanks which may be operated in any desired flow pattern. These tanks provide an average detention period of 24 hours at the plant design flow of 20 MGD, which is from three to six times the aeration period normally provided for treatment of municipal sewage. This is an indica-

Figure 4 — Architectural rendition of Cyanamid activated sludge plant, Bound Brook, New Jersey.

tion of the added difficulty of treating the complex wastes from the Bound Brook manufacturing plant as compared with an equivalent volume of municipal sewage.

Six 80-foot diameter sedimentation basins have been provided for removal of the biological sludge, which is returned to the aeration tanks for treatment of the incoming wastes. The overflow from the settling tanks is chlorinated and discharged into a small brook leading to the Raritan River.

The plant has been designed for maximum flexibility to allow future changes in its method of operation and to insure maximum efficiency at all times. Since a plant tour is scheduled to follow this meeting, we will not discuss the details of plant design here.

The structures at the right side of Figure 4 show the Somerset-Raritan Valley Sewerage Authority plant, which now is under construction. This plant will provide primary treatment for the sewages of Somerville, Raritan and Bridgewater Township. The settled sewage then will be delivered to the Cyanamid plant for joint secondary treatment prior to discharge into the river. Secondary treatment of the sewage will be provided by Cyanamid at a charge equal to the cost incurred for extra electrical power, chlorine and laboratory charges, but with no charge for capital costs or amortization.

SUMMARY

The pollution problem in the Raritan Valley has been reviewed briefly, indicating that undesirable conditions in the river had resulted from and increased with rapid municipal and industrial growth of the area. Cyanamid has been faced with a complex problem in treatment of wastes from its Bound Brook manufacturing operations over many years and, in particular, in development of a practical method for BOD removal through biological treatment. The Company's activities in wastes treatment have been reviewed briefly, covering a period of over 20 years, beginning prior to construction of an extensive wastes treatment plant in the late 1930's and leading up to construction of the plant which was started up on May 21. This plant will be shown in detail during guided tours to follow this discussion.

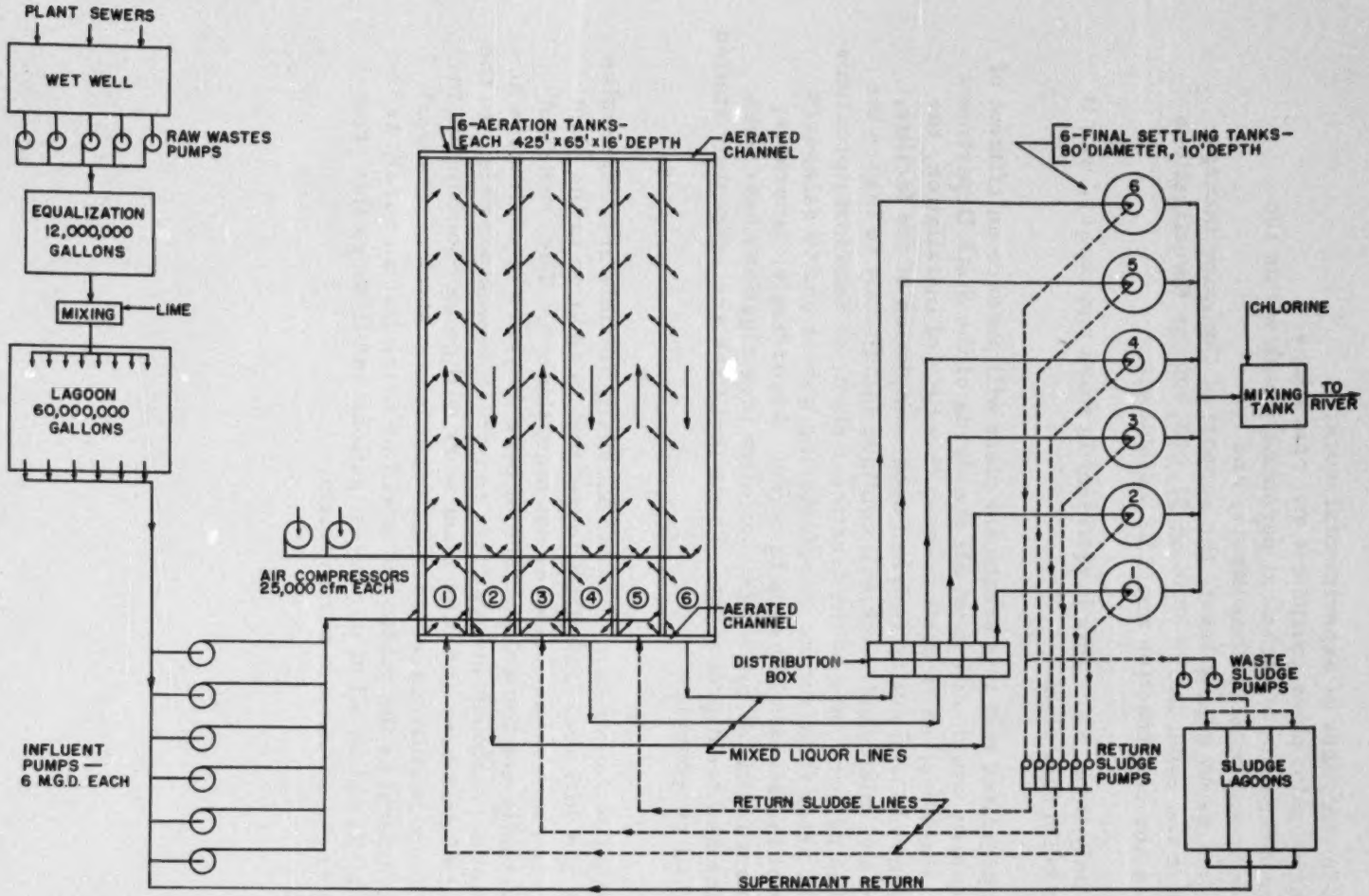
Before any plant could be built, it was necessary to develop a workable treatment process. This process had to be a reliable biological type of treatment unit, capable of handling a most complex chemical waste. To develop this process required:

(a) eight to ten years of experimental work,
(b) extensive pilot plant equipment and operations,
(c) the best thoughts of technical personnel, both within the Company and outside consultants, and
(d) last, but by no means least, the support of Company management in the expenditure of about $1,000,000 for investigations before any construction could be undertaken.

Then, and only then, after this investment in work and money, was it feasible to build this plant.

It is anticipated that this treatment plant will produce an effluent of very high quality which will meet all standards of the State Department of Health. However, as is customary in this type of installation, the work of Cyanamid will not be finished upon completion of the facility. Laboratory and pilot plant work will continue indefinitely to insure the best possible performance of the treatment plant, to anticipate problems which might arise from future manufacturing wastes and to safeguard the quality of the stream in years to come. Accordingly, laboratory and pilot plant facilities for waste treatment investigations have been built into the new treatment plant. These facilities are adequately staffed with technical personnel.

This plant is rather complicated, unusually flexible and impressive in size, as you will see. But don't forget that in addition to the plant itself there is much more that does not meet the eye. The treatment facilities actually are the culmination of over 20 years of continuous activity in wastes treatment before their construction was possible. In the future, much laboratory and pilot plant work will go on continuously to insure optimum performance under all conditions. Much of this work may not be evident to the public but it will be there just as surely as the plant itself. Based on all of our investigations and findings this treatment plant is the solution to our problem.



Flow sheet for waste treatment facilities, American Cyanamid Company, Bound Brook, New Jersey

Design Data - Waste Treatment Plant
American Cyanamid Company
Bound Brook, New Jersey

FLOWS

Average daily flow	17.0 mgd*
Maximum daily flow	25.0 mgd
Minimum daily flow	7.0 mgd
Basic plant design flow	20.0 mgd
Maximum hydraulic design flow	37.0 mgd

RAW WASTES CHARACTERISTICS

Biochemical Oxygen Demand (BOD)

Average concentration,	300 ppm**
Maximum concentration,	500 ppm
Minimum concentration,	150 ppm
Average pounds/day	43,000

Acidity (expressed as equivalent H_2SO_4 to pH 4.0)

Average	40.0 tons/day
Maximum	80.0 tons/day
Minimum	0 tons/day

pH, approximate average	2.0

EQUALIZATION BASIN

Volume	19.0 million gals.
Depth	12.0 feet
Detention period	22.8 hours

NEUTRALIZATION FACILITIES

Mixing tanks:

Number	2
Size each tank:	
Length	22 feet
Width	20 feet
Water depth	23.5 feet
Detention period of each (20 mgd)	5.5 minutes
Mixer H.P., each tank	30
Number points for controlled lime addition	2

Lime Slaking:

Number slakers	1
Capacity	5000 lbs. lime/hr.

Dry lime storage	40 tons

Lime slurry storage:

Number tanks	2
Total volume	425,000 gals.

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* mgd - millions gallons per day
** ppm - parts per million

SETTLING AND EQUALIZATION LAGOON

Number	1
Area	20.5 acres
Average depth	9 feet
Volume at average water level	53.2 million gals.
Volume at maximum water level	70.3 million gals.
Volume at minimum water level	40.0 million gals.
Average theoretical detention period (20 mgd)	2.7 days

INFLUENT PUMPING STATION

Design flow	30.0 mgd
Variable speed pumps:	
Number	3
Capacity, each	6.0 mgd
Constant speed pumps:	
Number	3
Capacity, each	6.0 mgd

AERATION TANKS

Number	6
Design flow	20.0 mgd
Detention period at design flow	24.0 hours
Max. hydraulic design flow	37.0 mgd
Dimensions of each tank:	
Length (including aerated channels)	425 feet
Width	65 feet
Depth	16 feet
Volume each aeration tank	3.3 million gals.
Number "Step Gates", each tank	16
Number of rows of air diffusers, each tank	2
Aerated channels:	
Number	2
Width	4 feet
Depth	16 feet

AIR COMPRESSORS

Type	centrifugal
Number	2
Capacity each	25,000 cfm*
Design pressure	8.0 psi
Motor horsepower, each	1000 hp.

FINAL SETTLING TANKS

Number	6
Design flow	20.0 mgd
Max. hydraulic design flow	37.0 mgd
Dimensions of each tank:	
Diameter	80 feet
Depth	10 feet
Detention period at design flow	2.7 hours
Surface overflow rate at design flow	660 gal./sq. ft./day
Weir overflow rate	10,000 gals./ft./day

RETURN SLUDGE PUMPS

Number, variable speed	6
Capacity, each pump	0.7 mgd
Total capacity, per cent of influent design flow	22

* Cubic feet per minute.

WASTE SLUDGE PUMPS

Number	2
Capacity each pump	1.1 mgd

CHLORINATION FACILITIES

Chlorinators and evaporators:	
Number each	2
Capacity each	4000 lbs. /24 hours
Mixing tank:	
Number	1
Type of mixing	baffles
Dimensions:	
Length	43 feet
Width	20 feet
Depth	10 feet
Volume	64,000 gals.
Contact period in tank	4.6 minutes
Contact period, total	10 minutes

WASTE SLUDGE LAGOONS

Number	3
Total volume (Approx.)	30 million gals.
Depth	3 - 10 feet

SUMMARY OF SEMINAR

Dr. Bergsma

Actually, I think the material presented here today was so clearly presented that it hardly needs any repetition. However, it is true that when we think about pieces along some sort of a trail, we are apt to forget what the whole meadow or mountain looks like. I presume that this effort is intended to give such a brief summary that all may be able to put the parts together.

The first paper this morning by Mr. McKenzie reminded us that it is possible to use the air mass to dilute pollutants that may be injected into it, but that already history has revealed there are occasions when we have exceeded the physiological limits for such toxic products being introduced into the air. He pointed out that there is no known automatic or natural cleansing process occurring in the air itself, as we know does occur under some situations in water. It was pointed out that the rate of loading the air with pollutants is increasing. The national program has an emphasis on research including studies of the physical and chemical interactions of air pollutants and also on the effects upon human health and physiology. It was pointed out that the costs of the damage produced apparently already far exceed the cost of control for the techniques we now know about.

The second paper presented by Doctor Sachs told very briefly about the New Jersey State program and indicated that it includes investigative or research aspects as well as control and enforcement under the air pollution control commission codes. The major portion of the time was devoted to giving a summary of one study that was conducted on a state-wide basis. It was designed to get data concerning relative geographical distribution of particulate matter. It was done, among other reasons, for background information and for purposes of evaluating future control efforts. The state-wide trends so discovered revealed that lowest levels of air pollution occurred in summer time in terms of seasons, and at noon in terms of each day; that the highest concentrations of particulate matter were found in the months of December and January in terms of seasons, and in the mornings between six and ten in terms of each day. Because of the lower levels that always occurred at any site on such times as week-ends, holidays and certain seasons of the year and noontimes, it was found that even the areas that had the greatest concentrations of particulate matter in the air, nonetheless yielded about 25 per cent relatively clear samples and these were later described as light spotting. The light to moderate spotting occurred in places concerning

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which there is usually very little complaint from citizens, but when the spotting results were frequently heavy or above, by the method used, complaints were more common. A smoke index was designed and it yielded figures, for the several New Jersey sites tested for the whole year, of 107 to 301. It would appear that the method has general applicability.

Doctor Snow reminded us of certain basic principles, namely that in dealing with pollutants or control of air pollution, there are three main principles. First, there is a possibility of redesigning the processes in industry to reduce the pollutants that escape to the air; second, remove the pollutants themselves from the air effluent before discharge; and third, discharge the air effluent at times which are optimum from the standpoint of atmospheric conditions. He also pointed out that none of these three need necessarily be used by themselves but a combination based upon what is possible or feasible, both from a technical and from an economic point of view, might yield best results. Certain applicable techniques were discussed and he stressed that there was need for research. He pointed out the relatively greater physiological effects which are associated with smaller particulate size and contrasted this with the tendency for particle removers to remove the particles of larger size. Removal of the larger, heavier particles, of course, gives higher efficiency ratings because these ratings are based upon the percentage, by weight, of that which has been removed compared with the original mass.

Mr. McCallum stressed that the role of the Federal government in stream pollution control was principally supportive in character. He discussed something about the objectives and pointed out that the Public Health Service policy concerning stream pollution control covered three main areas, namely, research, technical assistance and grants. The grants also might be divided into three parts, namely grants for fellowships, for program development or expansion at state level, and finally for construction of sewage treatment plants and facilities at the local level. He reminded us that originally the principal problem was the presence of pathogenic bacteria in water and that presently our problem is increasingly one of non-living contaminants in our potable waters. He stressed that there was a growing public recognition of the need for good quality of water, and this for a variety of purposes. It was very clearly emphasized that we must use the same water repeatedly and not just pollute it and throw it away.

Mr. Shaw referred to the early laws in the State of New Jersey concerning stream pollution which went back into the late 1800's. He stressed that for approximately a quarter of a century it was a period of prolonged litigation which was perhaps tiresome for those who had to go through it, but nonetheless is a benefit to us now, because it established the unquestionable legal base for the operation. He also pointed out that this legal process of litigation is now very rarely used. He discussed the objectives of the State Stream Pollution Control Program, and he pointed out again that the population in New Jersey is not only very high, but he said that it was so distributed that pollution of any intra-state stream is almost certain to affect somebody else. He pointed out that 60 per cent of the area of New Jersey is potable watershed. New Jersey municipalities and industry have been constructing stream pollution control projects at the rate of $30,000,000 to $50,000,000 per year in recent years. A considerable number of smaller pollution problems remain to be faced in the immediate future. Again he stressed that the citizens are increasingly aware of the pollution problem, and they are demanding ever cleaner waters.

Doctor Renn told us something about the uses of what might be called biological survey data in streams to determine something about their pollution levels. He stressed that it is rather an expensive method and because of our present limitation of knowledge, it still has limited application. He pointed out that chemical criteria for determining the levels of pollutions of streams are easier to deal with than the biological data. He stressed that water that is able to support a great variety of biological life is usually easier to use for other purposes for which man is concerned. There are numerous difficulties at present in interpreting or using the biological data which one can obtain about a stream. Standardization has not yet been achieved for these techniques nor for their application in terms of interpretation. He stressed, however, that the intelligent use is of distinct value. We were reminded that aquatic life adjusts itself to varying factors and also that physical factors such as oil and slimes rather than toxic or chemical factors sometimes account for the damage which we see to aquatic life in our streams.

Doctor Lamb gave us a brief historical run-down of the stream pollution problem in the Raritan Valley, which of course makes us think first of all of the Raritan River. He pointed out the unusual growth of both industry and population in this valley. He pointed out that the river always had pollution in it from natural conditions which later had added pollution from the increasing numbers of farms, and finally had still more pollution added from our increasing numbers and sizes of communities and industries. He stressed that a point had been reached long

ago where simple dilution of these pollutants entering the stream was no longer enough to maintain satisfactory conditions. This was especially true in periods of low flow for which this stream has been noted. He stressed that the control efforts began in very noticeable fashion in the thirties and then he gave us a run-down on what the American Cyanamid Company has been doing to deal with water pollution problems created in its operations at this site since that time. You will recall the picture of the lagoon which was one of the first efforts. All of the liquid effluent was collected into one system, I presume, originally, partly because of normal development and partly to get it into this lagoon, but by the same token, that fact limited the application of some separation procedures that might have been useful except for the fact that it was no longer economical to redesign the collection system. He pointed out that their wastes are characterized by great quantities of acid and organic material, including colored pigments of many kinds, some of which, I presume, are not organic. He stressed that a considerable amount of research was done; that biological treatment of the wastes in this Company's operations was found to be feasible; that pilot studies were conducted to determine the best method among those possible and also to determine the size of the plant that would be needed to deal with these wastes coming from the anticipated loads of this plant. After considerable study the waste treatment method was selected and it was briefly described. He told us that during the last three years the various tests that have been run in the pilot plants have yielded results which give them great confidence that the new plant which has just been opened will indeed work as expected.